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EXTENSION RESEARCH PROPOSAL

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NifTAL Project

Maximizing Symbiotic Fixation of Nitrogen by Grain and Forage Legumes in the Tropics

University of Hawaii
College of Tropical Agriculture
Department of Agronomy and Soil Science

MAXIMIZING SYMBIOTIC FIXATION OF NITROGEN BY GRAIN AND FORAGE LEGUMES IN THE TROPICS

PROPOSAL FOR SUPPORT UNDER
THE AGENCY FOR INTERNATIONAL DEVELOPMENT
BY
THE HAWAII AGRICULTURAL EXPERIMENT STATION
COLLEGE OF TROPICAL AGRICULTURE
THE UNIVERSITY OF HAWAII
HONOLULU, HAWAII

1 June 1978 - 31 May 1981

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PROJECT SUMMARY

A. Statistical

Project Title:	Maximizing Symbiotic Fixation of Nitrogen by Grain and Forage Legumes in the Tropics.
Project Phase:	Extension.
Contractor:	University of Hawaii
Principal Investigator:	Dr. A. Sheldon Whitney NifTAL Project P. O. Box "O" Paia, Maui, Hawaii 96779
Duration:	
Current Authorization:	June 1, 1975 - May 31, 1978
Proposed Extension:	June 1, 1978 - May 31, 1981
Total Estimated Cost:	
Through May 31, 1978:	932,307
06-01-78 to 05-31-79:	497,350
06-01-79 to 05-31-80:	733,660
06-01-80 to 05-31-81:	743,690
Total this request:	1,974,700
Total estimated cost:	$2,907,007
Project Specialist:	Dr. John Malcolm

B. Narrative

The NifTAL Project was conceived as a means of promoting and supporting legume-oriented programs throughout the tropics. The goal is to achieve greater exploitation of tropical legumes in developing countries and thereby provide a basis for increased production of high-protein foods with minimal dependence on nitrogen fertilizer.

The problems of increasing food production to keep pace with expanding populations is expected to become increasingly acute as the world's harvest of fossil fuels increasingly fails to meet energy demands. Consequent price adjustments will undoubtedly make the use of energy-intensive nitrogen fertilizer less cost-effective. The legume-*Rhizobium* symbiosis has a) the widest adaptability, and b) the greatest untapped potential for supplying both fixed nitrogen and high protein food and feed products.

NifTAL's purposes and objectives are designed to provide a foundation of tested rhizobial germplasm, improved inoculation methodology, a better understanding of the management of legumes for maximum nitrogen contribution to cropping systems, and a cadre of trained technicians; in order that the potential of tropical legumes can be more fully exploited in developing countries for the benefit of their farmers and consumers.

Since its inception in 1975, the NifTAL Project has 1) assembled a team of scientists and support staff to carry out research, service and training programs on nitrogen fixation by tropical agricultural legumes; b) developed research and training facilities appropriate for these programs; c) assembled a comprehensive collection of Rhizobium bacteria comprising of over 600 strains; d) carried out an aggressive screening program to identify superior Rhizobium strains with emphasis on strains which are effective on target grain legumes and are tolerant to acid soils; e) conducted research on the effects of soil and climate and management factors on nitrogen fixation by tropical legumes (e.g. shade, soil acidity, phosphorous and intercropping); and f) provided training in Rhizobium technology to 17 LDC junior-level scientists. Coordination of NifTAL programs with others in the tropics has been actively pursued through participation in international conferences and symposiums, hosting a workshop on "Exploiting the Legume-Rhizobium Symbiosis in Tropical Agriculture" and through visits to developing countries.

It is planned to continue these programs in the extension phase, and to develop a formal network of cooperating scientists in the developing countries who will collaborate with NifTAL in the testing of Rhizobium strains selected by NifTAL (and by cooperators), inoculation methodology, etc., under local conditions.

RESEARCH PURPOSE AND EXPECTED PRODUCTS

PURPOSE

The goal of the NifTAL Project is to reduce the dependence of LDC farmers on nitrogen fertilizer for the production of increased quantities of food. This will be accomplished by assisting *Rhizobium* and legume programs throughout the tropics to more effectively exploit the legume-*Rhizobium* symbiosis. Project purposes and associated objectives for the project extension are as follows:

A. Assemble comprehensive *Rhizobium* collection; select and characterize superior strains which are effective on economically-useful tropical legumes and are adapted to tropical conditions; and distribute same to researchers and inoculum producers.

1) Assemble additional strains of *Rhizobium* which are presumed to form effective associations with economically-useful tropical legumes.

2) Identify two or more superior strains of *Rhizobium* for each tropical legume of major importance and one or more superior strains for each legume of lesser importance. A superior strain is defined as one having one or more of the following characteristics:

   a. Highly effective on one or more target legumes.
   b. Infective and persistent in acid soils.
   c. Infective on host legume in competition with native rhizobia.
   d. Tolerant to high soil temperature.
   e. Effectively nodulate a wide spectrum of legume hosts.
   f. Have growth characteristics which are compatible with inoculant manufacture.

3) Establish a network of collaborators and provide assistance in standardizing, coordinating, and advising a series of field trials to evaluate potential "superior" strains in various regions throughout the tropics.

4) Distribute information on strain performance and characteristics to *Rhizobium* workers throughout the tropics.

5) Provide cultures of *Rhizobium* strains to researchers and inoculum producers throughout the tropics (upon request).

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B. Develop systems for improved inoculum delivery, and for ensuring dependable effective inoculation in the field.

1) Evaluate alternative carriers and packaging materials suitable for inoculum delivery in tropical LDC's.

2) Evaluate the feasibility of using fungi known to enhance rhizobial growth as components of Rhizobium inoculants.

3) Develop improved inoculation techniques for use a) where promiscuous legumes are grown in soils containing ineffective or partially-effective strains of Rhizobium; b) under high temperature conditions; and c) in acid soils.

C. Develop improved techniques and cultural systems to more fully exploit the nitrogen contribution of legumes to tropical cropping systems.

1) Define the nitrogen contribution of selected legumes in intercropping systems under various levels of competition by the associated crop for sunlight and nutrients.

2) Determine the effects of soil acidity, phosphorous nutrition, and soil nitrogen on nitrogen fixation by selected determinate and non-determinate tropical legumes at various stages of growth.

3) Devise and test methods designed to ameliorate the adverse effects of associated-crop competition and excess soil nitrogen on nitrogen fixation.

4) Determine the effects of soil and cultural factors on the short-term efficiency of legume residue as nitrogen sources for subsequent crops.

D. Train technicans for applied research and technology in Rhizobium bacteriology and in cultural techniques for maximizing nitrogen fixation.

1) Conduct three 5-week training courses in Rhizobium Technology.

2) Provide 2-24 month intern-type training experiences for LDC workers.

3) Support 4-5 graduate-research assistants.

EXPECTED PRODUCTS

A. A *Rhizobium* germplasm collection consisting of approximately 300 strains in the active collection and 500 strains in the inactive (reserve) collection--providing a valuable resource for legume and *Rhizobium* programs in the tropics.

B. A foundation of tested rhizobial strains which can be recommended for specific legume crops and for legumes grown under various stress conditions.

C. Improved methods for inoculum delivery and inoculation of legumes under tropical conditions.

D. Improved methods for maximizing nitrogen fixation by legumes in multiple-cropping systems, including methods for residue management.

E. A cadre of trained technicians in developing countries who are skilled in *Rhizobium* methodology or in cultural techniques for maximizing N fixation by tropical legumes.

PROGRESS OF THE PROJECT

A. Planned Output

A comprehensive *Rhizobium* collection containing 600 cultures in 2 years, 1000 strains with at least 5 cultures for each target legume by the end of the projected life of the project (10 years).

Progress and Comments

The initial goal of 600 cultures in 2 years has been attained and no difficulty is seen in obtaining a total of 1000 cultures or in obtaining five cultures of each target grain legume. The collection presently holds at least 14 isolates from each target grain legume except *Vigna mungo*, but there is little doubt that many isolates already in the collection will prove highly effective on this legume. The collection also holds at least 5 isolates for 9 out of 15 target pasture, green-manure, cover-crop, and vegetable legumes.

The collection, it is now clear, will need to be divided into an active and an inactive (reserve) collection as the screening work proceeds. The active collection will hold those strains judged to be worthy of utilization or further testing and will be listed with the World Data Center for Microorganisms. All other strains should be lyophylized and held in inactive storage.

B. Planned Output

At least one superior strain for 3 target legumes in 3 years; for all target legumes by end of project (10 years).

Progresss and Comments

Initial screening in the growth room and greenhouse has been proceeding at a rapid pace and effective strains have been identified for 6 out of 10 target grain legumes. The collection also contains effective strains tested by others for an additional 3 target grain legumes. Good progress has also been made in selecting *Rhizobium* strains tolerant of acid soil conditions through the subcontract with the University of California - Davis (D. N. Munns).

However, field confirmation of strain performance has proved to be slower and more difficult than anticipated. Field tests have been conducted with soybean and *Vigna* spp. and more are planned, but it appears that most of the field confirmation work must be deferred to the extension phase of the project.

C. Planned Output

One workshop involving approximately 50 scientists within 16 months.

Progress and Comments

This has been completed and the proceedings published. However, there is a continuing need to promote increased collaboration through a network of cooperating research scientists.

D. Planned Output

One tested technique for increasing inoculation dependability within 3 years.

Progress and Comments

This work is scheduled for the current project year, with special emphasis on techniques for minimizing the effects of high temperatures.

E. Planned Output

Define lime and phosphorous responses for N-fixation by tropical target legumes, and evaluate techniques for legume residue management within 3 years.

Progress and Comments:

Lime responses were evaluated for a wide range of legumes during the cold season of 1977 and an additional trial is now underway for the warm season (1977), involving fewer legumes but several varieties of each legume.

Phosphorous responses will be defined in the field and in the greenhouse for soybean and cowpea during the current project year.

Mineralization of N from leaf tissue was compared to urea-N in the greenhouse (5 legumes) and in the field (1 legume). Additional work on mineralization of residues of varying C:N ratio should provide a basis for devising more efficient residue management techniques. However, it is not clear that these techniques could be evaluated within 3 years. This work appears worthy of continued investigation since the short-term efficiency of the nitrogen in legume residue is often only about 50% of that of mineral N fertilization.

F. **Planned Output**

Train 24 LDC technologists within 3 years.

Progress and Comments

Seventeen junior-level scientists have been trained in *Rhizobium* technology to date in 6-week training courses conducted by NifTAL. A final course is scheduled for February/March 1978. Response from trainees who have completed the course have been quite satisfactory to date. There appears to be a continuing demand for this type of training and for short courses for senior-level scientists.

G. Planned Output

Train four M.S. (or higher-level) graduate students within 3 years.

Progress and Comments

Four graduate research assistants were hired during the second year of the project, and are well along in their course of study and research. It is anticipated that all will complete their work by the end of 1978. The project has also hosted two Ph.D. students supported by outside funds who have carried out legume research on a) shading effects on N-fixation, and b) legume performance when intercropped with grasses with and without N fertilizer. These students have had excellent symbiotic relationships with the project.

SIGNIFICANCE AND RATIONALE FOR EXTENSION

A. Importance of the Problem

1) The rapid growth of the world's population will create the need for additional protein to feed 2-3 billion more people by the year 2000, but crop land per capita has shrunk from 4 acres to 0.9, and will further shrink to 0.5 acres per capita by the year 2000[1].

2) "The United Nations, the Central Intelligence Agency, the Congressional Budget Office, the Office of Technology Assessment, the Stanford Research Institute, M.I.T., EXXON, Ralph Nader and the League of Women Voters--all these and more have offered assessments of the world's energy outlook[2]." Steiger makes the point that even the optimists predict increasing scarcity of oil no later than the late 1990's, and that this will force difficult choices as to the utilization of this increasingly expensive resource. Since nitrogen fertilizers are extremely energy intensive, it seems safe to predict that the utilization of nitrogen fertilizer to achieve increases in food production will become less and less cost-effective.

3) Even in the U.S., shortages of nitrogen are predicted to recur in the early 1980's, due to equipment obsolescence, shortages of feedstock, and increasing demand[3].

4) In the developing countries which must purchase their fertilizer (or energy) with hard currencies, this competition for nitrogen fertilizer (or energy) will create additional problems in providing additional fertilizer to support increased food production.

5) There are many LDC farmers who are unable to afford or obtain N fertilizers even if they are available to those with cash purchasing power near means of transportation.

6) Symbiotic nitrogen fixation by legumes is the only agriculturally viable system which is both widely adapted to all agrarian areas, fixes substantial quantities of nitrogen and yields high-quality foods and feed products.

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[1]David Pimentel (Professor, Cornell University). Interview in The Honolulu Advertiser, April 5, 1977.

[2]Paul E. Steiger (Los Angeles Times Service). Syndicated article in The Honolulu Advertiser, July 4, 1977.

[3]Gerald G. Williams, et. al. (Director, Division of Agricultural Development, National Fertilizer Development Center). Proceedings 1976 Hawaii Fertilizer Conference, April 1976.

Prospects for utilizing exotic systems through genetic manipulation are conceeded to be still far in the future[4].

7) The status of international research efforts in the food legumes has been rated by Dr. R. W. Cummings, Jr.[5] as seriously-to-critically inadequate in every area of the world. This means that a) yield levels are static to declining, b) actual yields are less than one-half or less than one-fourth of potential yields, and c) local institutions have only limited ability to apply new technology or have been initiated only recently.

8) Rhizobium technology has the potential for becoming accepted in developing countries. In India, there are now over 40 private and public inoculum producing units whereas there were only six public units and one private unit in 1970[6].

9) The role of NifTAL in this context is to assit Rhizobium and legume programs throughout the tropics to apply available technology to more effectively exploit symbiotic nitrogen fixation as a means of increasing food production with minimal dependence on nitrogen fertilizer. This can be accomplished through providing a foundation of tested rhizobial germplasm, improved inoculation methodology, a cadre of trained technicians, and a better understanding of the nitrogen contributions of legume in cropping systems.

B. State of the Art

The interest in alternatives to nitrogen fertilizer has developed in several ways since the Arab oil boycott of 1973/74. This has included additional emphasis on the Azolla anabena symbiosis as a source of nitrogen for paddy rice, nitrogen fixation by micro-organisms living in the roots or rhizospheres of grasses (including rice), and on genetic manipulation of N fixing micro-organisms. However, the legume-Rhizobium association has been generally recognized as making the most contribution to agriculture at present and having the greatest potential for increase.

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[4]R. W. Cummings, Jr. Food crops in the low income countries: The state of present and expected agricultural research and technology. Rockefeller Foundation--Working Paper, May 1976.

[5]J.L.M., Nitrogen Fixation: Prospects for Genetic Manipulation. Science 196: 638-640, May 1977.

[6]V. P. Sahni (Vice-President, Bactogin Laboratories, Jabalpur, India). Inoculants for India. Proceedings NifTAL Workshop on Exploiting the Legume-Rhizobium Symbiosis in Tropical Agriculture, August 1976.

In this area there have been four major and several lessor program developments which are significant to the overall research progress:

1) The establishment of the NifTAL Project itself must be considered a major development. The Rhizobium collection is probably second or third in the world (after the Nitragin Co. collection and probably the CSIRO collection at Brisbane) with respect to holdings of effective strains for a wide range of tropical legumes. The workshop held in August, 1976 provided interaction among a broad spectrum of Rhizobium and legume workers, and the proceedings are a significant addition to the literature on this subject. The training courses are beginning to have an impact as more trained technicians return to their homes with the skills and background to conduct good research.

2) ICRISAT's employment of Peter Dart from Rothamstead has given that center a strong role in the area of nitrogen fixation by chickpea, pigeon pea, and to a lesser extent, peanuts.

3) The bean program at CIAT has established a Rhizobium collection for various legumes, with emphasis on Phaseolus vulgaris, and has conducted some field tests of Rhizobium strains.

4) The ICRO Panel supported by UNESCO and UNEP has begun the establishment of Microbiological Research Centers (MIRCEN's), with the initial support for such centers going to the Department of Soil Science, University of Nairobi and the University of Federal do Rio Grande do Sul, Brazil. This additional support will enable these groups to significantly expand their programs, although the support is intended for fermentation, degradation, and other microbiology work in addition to the Rhizobium research.

5) Two Rhizobium researchers have recently been hired to work in Puerto Rico under AID auspices: Dr. Roger Smith (211-d supported; work on pigeon pea and inoculant problems) and Dr. Stewart Smith (INTSOY).

6) FAO interest in expanding the capability of LDC countries to carry out symbiotic N-fixation programs has been demonstrated by means of a survey in Latin America, assisted by Dr. Carlos Batthyani. The results of this survey are not yet published but should provide an excellent tool for planning for assistance programs in this region.

7) Several internationl conferences have been held on the subject, notably in Brazilia and Salamonca (Spain). Short training courses have also been sponsored by UNESCO and others, with the UNESCO courses having a relatively small Rhizobium component.

There are a number of strong research centers focusing on symbiotic N-fixation by tropical legumes. These include the following:

1) CIAT: Phaseolus beans, Stylosanthes spp.

2) ICRISAT: Pigeon pea, chickpea, peanut.

3) CSIRO Brisbane: Stylosanthes spp., Leucaena leucocephala.

4) Thailand:

   a) Ministry of Agriculture, Division of Plant Pathology: Soybean.
   b) Kasetsart University: Soybean, mungbean.
   c) Khonkhaen University: Soybean, mungbean.
   d) Chiengmai University: Soybean, mungbean.

5) India: A large number of universities are working with soybean, chickpea, pigeon pea, peanut, cowpea, and other legumes. The All-India Pulse Programme serves to loosely coordinate much of this work. Also, the India Standards Institute is working on inoculant standards for inoculants manufactured by the 40 functioning production units.

6) U.S.: North Carolina State University and Texas A & M University both have strong research programs on peanut and soybean Rhizobium. Most of the other significant U.S. programs are either in the North or are concerned more with basic research on soybean.

7) Brazil: Several centers, mostly with emphasis on soybean, including:

   a) Dr. Dobereiner's group at EMBRAPA, Km 47, Rio de Janeiro.
   b) Dr. Freires group at UFRGS, Porto Alegre, and
   c) Dr. Eli Lopez at Campinas.

There are also numerous smaller programs, including several in Mexico. Thus there are a variety of research programs presently involved in research on nitrogen fixation by legumes. However, aside from NifTAL, there are very few broadly-based Rhizobium collections or intensive training programs in Rhizobium methodology.

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There has also been a surge of interest in multiple cropping in recent years, and cropping systems research is being strongly supported by most of the international crops research centers. However, this work is usually not focused on maximizing the nitrogen contribution of the legume component, except at CIAT where N-fixation by beans associated with maize is being evaluated. Basic studies in ecology[1] have shown that the advantages for using crop mixtures are usually obtained only a) where inputs are low and/or b) when one of the components is a legume. Since the major reason for the importance of the legume is its ability to fix nitrogen, it seems clear that intensive work on N-fixation by intercropped legumes is needed in order to maximize the yield of the total cropping system.

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[1]Prof. C. T. de Wit Summary Statement, Proceedings Symposium on Plant Relations in Pastures, Brisbane, May 1976.

PLANS FOR RESEARCH COORDINATION

Informal agreements have been made with Rhizobium research laboratories specializing in specific crops to the effect that NifTAL will not duplicate their work, but will collaborate with them and will serve as repository for superior strains of Rhizobium identified by them.

1) CSIRO (Brisbane): Stylosanthes spp., Leucaena leucocephala

2) CIAT: Phaseolus beans, Stylosanthes spp.

3) ICRISAT: Pigeon pea, chickpea

4) North Carolina State University: Peanut

Linkages are being developed in countries throughout the tropics through the seventeen trainees who have completed the NifTAL Rhizobium technology course. Arrangements have been completed with most of the graduates of the first two courses to conduct studies on survival of Rhizobium shipped to their countries. Additional cooperative programs are planned, once this potentially limiting factor is better documented.

Contacts with scientists in developing countries have also been made through participation in regional meetings (e.g. Latin American Rhizobium Conference and the INPUTS meetings sponsored by the East West Center) and through travel, particularly in Southeast Asia. In addition, enquiries and expression of interest in cooperative programs have been received from laboratories in several other countries including India, Sri Lanka, Iraq, Sudan, Zambia, Mexico and Venezuela.

It is planned to pursue these contacts in the extension phase of the contract, and to develop other contacts through country visits and attendance at international meetings. From these contacts, regional coordinators will be selected and invited to Hawaii for a planning conference during the first year. Participants in this conference will a) identify host legumes to be employed; b) define experimental procedures; and c) identify potential cooperators in each region. The experiments presently conducted in cooperation with the Benchmark Soils Project and with training course graduates will provide an excellent basis for developing a standard protocol for tests to be conducted by LDC cooperators.

Regional conferences will be held during the second year of the contract in order to involve potential cooperators in setting goals and planning for the implementation of Rhizobium strain trials. Grants will be made to each regional coordinator and each cooperator in order to enable them to purchase needed supplies and for travel within their region or country. NifTAL will provide an experienced Rhizobium microbiologist to visit each cooperator (accompanied by the appropriate regional coordinator) during the second and/or third years.

PLANS TO FACILITATE UTILIZATION

A. Publication of a catalogue of NifTAL's "active" Rhizobium collection should be completed by the end of the present contract. This will continue to serve as an important tool for utilization during the extension phase of the contract. The catalogue will be revised during the second year of the extended contract.

B. The planning conference for regional coordinators and the regional conferences will be devoted in part to discussion of the present state of the art, including the results obtained under the contract program.

C. Papers will be presented at two or more appropriate national conferences and two or more international conferences to disseminate the results obtained by NifTAL.

D. Articles will be prepared for publication in scientific journals having wide distribution in the tropics (e.g. Rhizobium Newsletter, Plant and Soil, and Agronomy Journal).

E. Newsletters will be sent to graduates of the training courses and cooperators to keep them informed of progress by their colleagues and by NifTAL. No other newsletter is planned since the Rhizobium Newsletter provides a convenient vehicle for publicizing special findings or programs.

F. Results from the strain tests conducted by NifTAL and the cooperators in each region will be compiled annually and distributed to cooperators and other interested workers.

MANAGEMENT CONSIDERATIONS

A. Continuation of the same management team is contemplated for the project extension. The sub-contract with the University of California-Davis has proved to be highly productive and will also be continued.

B. The project work will continue to be carried out largely at the facilities near Paia, Maui, which have been made available to the project by the County of Maui. Only minor renovation work is required to accommodate the planned program of work.

C. The close working relationships which have been developed with the Benchmark Soils Project will be continued, with emphasis on determining the transferrability of information on Rhizobium strain performance on soils of the same family.

D. Training courses in Rhizobium Technology will be offered at sites other than Hawaii where facilities and personnel support are available. CIAT has already indicated their interest in hosting one course.

E. At this writing, a proposal for University of Hawaii participation in Biological Nitrogen Fixation research and development programs is being included in a consortion proposal for Title-XII funding. Certain aspects of this program--both at Hawaii and among other members of the consortion--will involve close coordination and cooperative effort with the NifTAL Project. No significant overlap is expected; rather the programs should prove complementary and synergistic.

G. The University of Hawaii College of Tropical Agriculture has adopted a broader commitment to international programs under the leadership of Dean W. R. Furtick. Some relief from the administrative workload is expected with the appointment of additional personnel within the college administration.

H. Evaluation of the project was conducted by a review team consisting of AID and USAID experts in February, 1977. It is expected that future project evaluation will be carried out using the same procedure, probably in late 1978. Additional administrative reviews will be arranged annually by the project manager.

TECHNICAL REVIEW

A. The technical basis for the approach taken toward screening for superior Rhizobium strains is discussed in the original proposal. Work to date confirms in general, the hypothesis that it is possible to select strains of Rhizobium which are unusually effective on one legume or a wide range of legumes or are unusually tolerant to soil stress factors such as high soil Al or Mn, low soil Ca, high soil temperature, etc.

B. A large number of the legumes used agriculturally in the tropics are nodulated by a group of Rhizobium known collectively as the "cowpea miscellany". These Rhizobium are slow-growing compared to the rhizobia associated with most temperate legumes. The taxonomy of this group has proved very complex, and is therefore largely unresolved since their associations with legume hosts do not generally follow legume taxonomy. The legumes nodulated by this group are usually considered to be rather promiscuous, but many of these legumes do exhibit a moderate-to-high degree of specificity (e.g. Sphenostylus, Sesbania, Canavalia, and Leucaena). There is, therefore, opportunity to select highly effective strains for these legumes with a reasonable expectation that inoculation responses will occur where these plants are introduced into new areas. There are also a number of cool-season legumes such as Lens, Cicer and Vicia spp. which are grown in tropical latitudes, but are nodulated by fast-growing Rhizobium and are relatively specific in their strain requirements. These too are prime candidates for achieving responses to inoculation.

C. The development of small inoculum production units in S.E. Asia, India, and elsewhere has intensified the search for suitable inoculum carriers and packaging materials. Bagasse (a sugarcane by-product) has been tried on a number of occasions but gives lower survival rates than peat. Sugar mill filter mud has also been tested and is superior to bagasse. However, both have sucrose contents that favor the growth of antagonistic fungi. Other materials which are presently being used in various places include lignite, compost, soil, and coconut coir. There is a need for a concerted testing program to identify the best materials for use under tropical conditions. Also, since most of the materials must be sterilized by autoclaving before use, it is not feasible to prepackage the carrier in polyethylene bags. Work is needed to identify the most suitable packaging materials for use where the carrier must be autoclaved.

D. Work by NifTAL and others has shown that the conditions for acceptable yield of N-fertilized legumes may be unacceptable for symbiotic legumes. Shading, for example, reduces root-growth and N-fixation to a much greater extent than top growth. Also,

infection by *Rhizobium* may be inhibited at low pH levels, depending on the plant species. However, the available information regarding the effects of factors such as soil acidity (high Al, and Mn, low Ca), shading effects, and nutrient competition is extremely deficient for nearly all the tropical legumes.

RESEARCH DESIGN AND METHODS

1. Summary of Major Activities

		Month to Start	Month to Complete
A-1.	Assemble additional *Rhizobium* strains:		
	a. assemble additional 130 strains (for total of 800)	1	18
	b. assemble additional 100 strains (for total of 700)	18	36
A-2.	Identify superior *Rhizobium* strains (≥ 2/secondary legume):		
	a. greenhouse testing, select one strain each major sp., one strain for half of secondary spp.	1	12
	b. greenhouse -- all remaining tests	12	30
	c. field testing of strains chosen in (a.)	8	24
	d. field testing of strains chosen in (b.)	21	36
A-3.	Establish network of collaborators:		
	a. planning conference in Hawaii	9	9
	b. regional conferences	12	24
	c. visits to cooperators	13	36
A-4.	Update and distribute *Rhizobium* catalogue:	12	18
A-5.	Distribute cultures:	1	36
B-1.	Evaluate inoculum carriers and packages:	1	18
B-2.	Test fungi for *Rhizobium* inoculum:	6	36
B-3.	Develop improved inoculation techniques:		
	a. for soils with background cowpea	1	36
	b. for high temperature conditions	1	24
	c. for acid soils	1	36

		Month to Start	Month to Complete
C-1.	Define intercrop competition effects on N-fixation by legume component:	2	34
C-2.	Define N, P, and lime responses; N-fixation by determinate and non-determinate legumes:		
	a. N effects, determinate and non-determinate	2	21
	b. P responses	1	12
	c. Lime and calcium responses	2	29
C-3.	Test methods to minimize N-fixation depression due to high N, other crops:		
	a. methods to overcome high N effects	18	36
	b. methods to overcome competition, other crops	24	36
C-4.	Define soil and management factors limiting efficiency of legume-residue N:	1	24
D-1.	Three *Rhizobium* technology training courses:	5	30
D-2.	Intern-type training	By arrangement	
D-3.	Graduate Research Assistant training	1	36

2. Experimental Methodology

Additional *Rhizobium* strains will be solicited from existing collections with preference given to local strains previously documented and tested. Isolations from nodules will be made in order to obtain cultures for specific requirements (e.g. less important legumes or acid soils). Each acquisition will be tested for authenticity by inoculating the host (or rarely, *Macroptilium atropurpureum*) and checking for N-fixation. Authentic *Rhizobium* will be assigned to either the active or inactive collection depending on the assessed potential for future testing. Strains assigned to the active collection will be characterized by standard laboratory tests and registered with the World Data Center for Microorganisms.

Selected strains from the active collection will be subjected to further testing in order to identify superior strains. Testing for strains tolerant of conditions typical of highly weathered soils will be conducted under the auspices of the sub-contract with the University of California-Davis (Dr. D. N. Munns). Initial screening will be done using modified Leonard jars in the greenhouse, replicated as needed. Promising strains from these trials will then be tested in field trials, both in Hawaii and by cooperators in developing countries. All field trials will utilize a standard protocol which can be adapted to local conditions and will involve measurements of plant heigh, acetylene-reduction activity (where feasible), nodule weight, and yield. Serological identification of the Rhizobium strains actually producing the nodules in overseas tests will be done by NifTAL, or done by cooperators who are competent in serology with frequent confirming checks by NifTAL microbiologists.

The criteria for superior strains include competitive ability and persistence, and these will be evaluated using serological analysis of organisms recovered from nodules or from soil using both gel-diffusion and fluorescent antibody serological methods. Similar techniques will also be used to evaluate the effectiveness of various inoculation methods. Tolerance to high temperatures will be evaluated by incubating broth, peat, and soils containing the organisms at 35-40C for varying periods of time.

Evaluation of inoculum carriers and packaging techniques will be by determining a) growth and b) persistence of the Rhizobium in various combinations of carriers, packages, and carrier-sterilization methods and under other conditions such as range in age of inoculum, temperature variation, etc. The potential for using beneficial fungi in Rhizobium inoculum will be evaluated very similarly, using cultures of fungi already available to NifTAL which have been observed to enhance the growth of Rhizobium under certain conditions.

Studies of the effects of soil acidity, phosphorus, and nitrogen nutrition, and crop competition on N-fixation by different types of legume plants will be carrier out using standard field and greenhouse experimental techniques, except that in some cases, continuous function experiments will be used to evaluate the plant response to a continuously changing rate of application of soil amendment or plant nutrient. Crop competition effects will be determined using legumes intercropped with maize or other non-legumes (e.g. sweet potato), and the residual N will then be evaluated using a follow-up crop of wheat or forage grass.

The effects of various soil and management factors on the efficiency of legume residues as sources of N for subsequent crops will be approached by screening a wide variety of legume residues (on an equa'-N basis) to determine those with the greatest efficiency. These will then be thoroughly analyzed in order to identify criteria which would be useful in screening larger numbers of varieties.

TOTAL COST ANALYSIS

The estimated extension budget from 1978-79 to 1980-81 is $1,974,700. Not included is the support from the University of Hawaii (Hawaii Agricultural Experiment Station); and cooperators and coordinators from LDC institutions throughout the world.

Approximately $60,000 plus staff time is earmarked directly for training. However, indirectly, considerably more funds are involved in training because knowledge learned under other objectives of this program are passed on to the trainees. Five additional graduate students are expected to receive degrees under this program.

Similarly, although $94,000 (plus staff time) is budgeted for network costs, this is only a fraction of the total costs involved since most of the total research program is oriented toward this testing of project germplasm and techniques in the LDC's.

Additional funds are necessary to add personnel, travel, equipment and supplies, and services in order to meet the objectives of the program. A proposed budget is as follows:

		1978-79	1979-80	1980-81
A.	Direct Costs			
	1) Salaries (Workmonths)	228,100 (175)	331,340 (249)	356,750 (249)
	2) Fringe Benefits	40,800	60,400	64,000
	3) Consultants	4,000	5,000	5,000
	4) LDC Network Costs	10,000	45,000	39,000
	5) Travel and Subsistence	19,000	27,700	28,400
	6) Participant Costs	18,000	19,800	21,800
	7) Freight to LDC's	---	10,000	6,000
	8) Publications	3,000	6,000	6,000
	9) Equipment and Supplies	60,000	79,800	58,500
	10) Vehicle Lease	6,200	6,800	7,200
	11) Subcontract (U.C.-Davis)	35,250	35,790	36,880
B.	Indirect Costs	73,000	106,030	114,160
C.	Total Contract Funds	497,350	733,660	743,690

WORK PLAN

Purpose A:

Assemble comprehensive Rhizobium collection; select and characterize superior strains which are effective on economically-useful tropical legumes and are adapted to tropical conditions; and distribute same to researchers and inoculum producers.

Activities required to achieve this objective include: authentication and testing of strains for effectiveness on target legumes in growth-room or greenhouse tests using modified Leonard jars; characterizing those strains selected from the active collection by various laboratory tests; maintaining documentation on all strains; preparing cultures for storage, and preparing cultures for sending to recipients.

A major increase in research activity is planned in order to field-test selected strains (against locally-selected strains where feasible) at locations throughout the tropics. This will involve the establishment of a formal network of cooperators as discussed earlier. Distribution of information on strains held in the active collection is expected to be accomplished through the auspices of the World Data Center for Microorganisms.

Inputs needed will include the major time allocation of two professional microbiologists and three research associates including an assistant curator of the collection. One or two graduate students will also be involved in this work. Little additional equipment is required; but large quantities of consumable supplies are involved, and modifications of the growth-room and greenhouse are needed to upgrade the testing program. The establishment of a formal network of cooperators for field-testing of rhizobia will require the employment of a senior coordinator; a large travel budget to cover transportation and subsistance for the initial and regional conferences plus trips within the regions; and a system of grants to regional coordinators and country cooperators.

Purpose B:

Develop systems for improved inoculum delivery and for ensuring dependable effective inoculation in the field.

The activities planned for objective B include: the testing of a wide range of possible inoculum carriers and packaging materials with emphasis on easily-obtainable materials which can support the growth and adequate survival of Rhizobium bacteria; testing the possibility of including beneficial fungi in inoculum preparations; and testing a variety of techniques designed to enhance the survival and persistence of introduced Rhizobium in

soils containing a background of less-effective strains or in which high temperatures occur at the surface. These will include studies of placement, inoculum carriers, inoculum size, and use of co-applied amendments. This work will require recovery of nodules from plants grown at various intervals after inoculation, and identification of the Rhizobium strain responsible for nodule initiation by serological methods.

These labor intensive activities will require part-time work by two microbiologists, two technicians, and one graduate assistant. Some additional serology equipment will also be required to expedite the typing of large numbers of nodules and for identifying Rhizobium strains in soil.

Purpose C:

Develop improved techniques and cultural systems to more fully exploit the nitrogen contribution of legumes to tropical cropping systems.

Planned research activities include field experiments in which nitrogen fixation of selected legumes is determined when grown with associated non-legumes. Cultural systems will be utilized which result in different degrees of intercrop competition for nutrients and sunlight in order to a) determine the relative influence of these factors, and b) devise improved techniques for minimizing competition effects on N-fixation. These then will be tested in subsequent field experiments. Additional field experiments will be conducted to define the effects of soil pH (including Al and Ca levels), soil phosphorous, and soil nitrogen levels on N fixation by several varieties of selected grain legumes. These will be supplemented with greenhouse tests using re-circulating culture solutions to more precisely define these responses with minimal interference from other factors. N-fixation by determinate and non-determinate varieties of Vigna and Phaseolus spp. will also be compared, especially with respect to tolerance to high soil N levels. The efficiency of legume residues as N sources for subsequent crops will be evaluated at first in incubation studies in the laboratory and greenhouse, using materials of various C:N ratios, and then checked with simple field experiments on both highly and moderately-weathered soils.

The program of work will require two professional agronomists and at least two technicians plus two graduate assistants. It will also be necessary to assure the capability of analyzing large numbers of samples for nitrogen content and to upgrade the greenhouse facilities. Only moderate amounts of supplies are required for these activites, but adequate vehicle support is essential.

Purpose D:

Train technicians for applied research and technology in *Rhizobium* bacteriology and in cultural techniques for maximizing nitrogen fixation.

The training programs will include revision of the present course to reduce the length to 5 weeks and to accommodate up to 10 students; conducting the course once each year (at least once in a regional location such as CIAT); providing intern-type training experiences for LDC workers who wish specialized training in research techniques; and providing training for 4-5 graduate research assistants during their course of study and research.

These activities will require part-time attention by one microbiologist and at least half-time work by one technician for the training courses, plus 10-15% attention by all the professional staff toward the training of interns and graduate students. Additional training equipment (especially microscopes) and supplies will be needed in order to enlarge the course and to provide for graduate student research.

SUB-CONTRACT

Subcontractor: University of California-Davis

Title: Effects of Soil Chemical Environment on Symbiotic Performance

Principal Investigator: Donald N. Munns, Professor of Soil Science

Rationale and Scope of Work:

Many soils of the tropics which are or can be used for agriculture are low in exchangeable bases, low in phosphorous, and often have toxic levels of active aluminum or manganese. It is therefore of great importance to be able to select strains of *Rhizobium* which are as tolerant as possible of these conditions, and to be able to accurately diagnose and determine critical levels of lime and/or nutrients which are required to assure adequate symbiotic performance on thse soils.

Dr. D. N. Munns at the University of California-Davis Campus has an excellent reputation in this field, has adequate facilities to conduct such research, and has made excellent progress in identifying and characterizing acid tolerant rhizobia during the initial phase of the contract. Continuation of the sub-contract is therefore strongly recommended.

The work will focus on the following problem areas:

1) Continued screening of *Rhizobium* strains for tolerance to soil acidity and phosphorous deficiency using strains appropriate for *Vigna*, *Cicer*, *Lens*, *Arachis*, *Phaseolus* (low P only), *Cajanus*, *Psophocarpus*, *Voandzeia*, and selected forage legumes.

2) Methods of culturing *Rhizobium* strains so as to preserve adaptation to soil stress factors.

3) Diagnostic criteria and predictors of tolerance for host-*Rhizobium* associations under stress conditions including *Rhizobium* characteristics and soil testing methods.

4) Genetic variability of selected *Vigna* spp. with respect to tolerance to soil acidity.

Greenhouse and laboratory procedures have been developed during the initial phase to permit rapid progress on all but the last item; where much work will be required to elucidate the inter-relationships among soil stress, legume host, and *Rhizobium* performance.

GENERAL APPRAISAL

This project has been identified by TA/AO as being of high priority, and its extension for three years has been included in TA budget plans. The plan of action presented in the proposal may be expected to provide substantial benefits to LDC countries who must increase food production with minimum inputs. The cost estimates are appropriate for the planned level of effort.

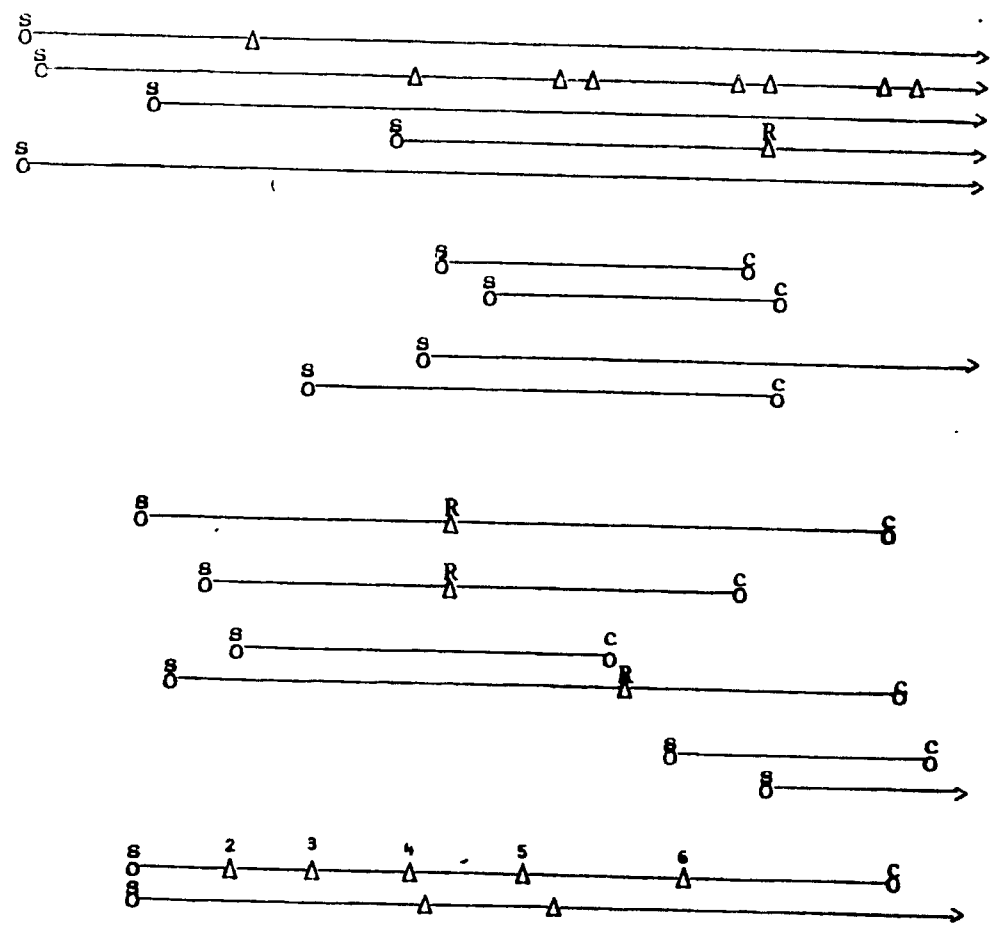
The project was reviewed by a team from AID and USAID in February of 1977. The review team found that the effort to date had been excellent despite start-up delays, and that continuing funding should be assured. The team acknowledge that the testing process, especially field testing was a slow one, and proposed a Phase II of greatly increasing activity (and funding), followed by a Phase III at this high level for a period of 9 years to enable a full program of field testing to be carried out.

APPENDIX A -- LOG FRAME

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
ram or Sector Goal: The broader ctive to which this project contributes: ncrease quantity and improve quality of produced by small and large farmers in ical LDC's. To reduce dependence of LDC farmers -fertilizers through greater exploitation itrogen fixation by tropical legumes.	Measures of Goal Achievement: Total protein yields to increase proportionally more than nitrogen fertilizer inputs in tropical LDC's over several cropping seasons. (Note: This may be impossible to measure statistically.) Sub: Reported instances of poor N-fixation corrected by LDC technicians in timely fashion and with minimum inputs.	FAO Production Yearbook. AID Missions.	Assumptions for achieving goal targets: 1) Nitrogen fertilizer to become increasingly costly for LDC farmers in relation to market grain prices. 2) Improved legume varieties with increased yield potential and reduced risk hazard become accepted by LDC farmers. 3) National programs will actively encourage greater exploitation of N fixation by legumes.
ect Purpose: semble comprehensive Rhizobium collection, lect and characterize superior strains fective on economic tropical legumes and stribute to researchers and inoculum oducers. velop systems for improved inoculum livery and for ensuring dependable fective nodulation in the field. velop improved techniques and cultural stems to more fully exploit N contribution legumes to cropping systems. ain technicians in Rhizobium bacteriology d cultural techniques for maximizing xation.	Conditions that will indicate purpose has been achieved: End of project status. (10 years) 1) Rhizobium strains suitable for tropical conditions selected and distributed to numerous workers in the tropics. 2) LDC technicians testing and adopting improved techniques and cultural systems. 3) Workshop and training courses held as scheduled.	1-3: Annual reports. On-site review. 3: Trained technologists, proceedings.	Assumptions for achieving purpose: 1-3: Hawaii conditions sufficiently similar to tropical LDC's for valid testing of germplasm and technology. - LDC's develop inoculant production capability. - Trained technicians have continuing opportunity to conduct N-fixation research.
uts: (Extension Phase) tive and reserve Rhizobium collections. perior Rhizobium strains. proved methods for inoculum delivery and oculation of legumes. proved methods for maximizing N-fixation cropping systems and for efficient ilization of legume residues. ained technicians. ained scientists.	Magnitude of Outputs: (Extension Phase Ending 05-31-81) 1) 300 strains in active collection, 600 strains in reserve collection (total 1000 strains end of project); catalogue distributed to over 100 workers. 2) Two superior strains/major legume; one superior strain for each remaining target legume; 40 cooperators involved in field testing program. 3) 10 potential inoculum carriers, 4 packaging materials and 2 beneficial fungi evaluated for inoculum production. One or more techniques for improving inoculation under stress conditions. 4) One or more techniques recommended for increasing N-fixation of intercropped legumes and for using legume residues more efficiently. 5) 30 trained technicians. 6) Four M.S. (or higher) graduate students.	1-2: On-site review, check by independent lab, catalogue distribution. 3-4: On-site review, annual reports. technical reports. 5: Certificates awarded. 6: Degrees awarded, published thesis.	Assumptions for achieving outputs: 1-3: No unreasonable quarantine restriction collaborative agreements can be formal with institutions concerned with N fixation in the tropics. 4: Suitable cooperators and field test sites available in LDC's 5: LDC's to assign technologists to Rhizobium work. 6: Students complete courses of study in timely fashion, course offerings on schedule.
ts: (Extension Phase) ersity of Hawaii ofessional staff in Rhizobium. chnical, administrative and support staff. boratory, greenhouse, field, office cilites and computer and analytical services. ancial support. ject management.	Implementation Target (Type & Quantity) 1) 285 man months (3 years) 2) 390 man months (3 years) 3) Adequate for project. 5) $1,374,700 (3 years)	1-3; Annual reports. 4-5: AID and U. of H. records.	Assumptions for providing inputs: 1-2: Qualified professional, technical and administrative personnel respond to recruitment. Minimum bureaucratic delays hiring. 3: Pais facilities continue to be available for project activities. 4-5: AID funding and project management provided.

APPENDIX B -- MILESTONE CHART

ACTIVITY	Initial Phase			Extension Phase		
	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81
A: Rhizobium Collection and Testing						
A-1 Assemble strains						
A-2 Identify superior strains						
A-3 Establish network of collaborators						
A-4 Distribute catalogue						
A-5 Distribute Rhizobium culture						
B: Inoculation Methodology						
B-1 Evaluate inoculum carrier packages						
B-2 Evaluate beneficial fungi						
B-3 Develop improved incoulation methods						
a) against ineffective soil population						
b) high temperature conditions						
C: Cultural Systems to Maximize N Fixation						
C-1 N contribution to Intercropped Legumes						
C-2 Lime and fertilizer effects on N fixation						
a) soil N, determinate vs. non-determinate legumes						
b) phosphorous nutrition						
c) lime and calcium responses						
C-3 Systems to maximize N fixation						
a) at high levels of soil N						
b) in competition with non-legumes						
D: Training						
a) 5-week Rhizobium technology courses						
b) Graduate assistants						



Δ = Interim goals

R Δ = Revision of program or catalogue

Δ = Planning conferences or training courses held

S o = Start

C o = Completion

Appendix C (page 1 of 2)

Detailed Budget

DESCRIPTION	1978-79 Mos.	1978-79 Costs	1979-80 Mos.	1979-80 Costs	1980-81 Mos.	1980-81 Costs	Total Mos.	Total Costs
SALARIES								
Microbiology								
Asst. Microbiologists	24	35,530	24	38,200	24	40,200	72	113,930
Technicians(Res.Assoc. II)	24	27,120	24	28,300	24	30,000	72	85,420
" (Res.Assoc. I)	12	11,500	12	12,100	12	12,770	36	36,370
Grad. Res. Asst.	12	12,000	12	12,600	12	13,300	36	37,900
Sub-subtotal	72	86,150	72	91,200	72	96,270	216	273,620
Agronomy								
Senior Agronomist	12	33,600	12	34,850	12	36,100	36	104,550
Asst. Agronomist	10	13,750	12	17,070	12	17,650	34	48,470
Agron. (Post. Doc.)	-	-	12	16,000	12	16,000	24	32,000
Technicians(Res.Assoc. I)	24	21,000	36	33,000	36	35,400	96	89,400
Grad. Res. Asst.	12	12,000	18	18,600	18	19,600	48	50,200
Sub-subtotal	58	80,350	90	119,520	90	124,750	238	324,620
Extension								
Ext. Sen. Microbiologist	-	-	12	28,100	12	29,400	24	57,500
Asst. Microbiologist	3	4,580	3	4,810	3	5,150	9	14,540
Asst. Curator(Res. Assoc II)	12	13,560	12	14,760	12	15,960	36	44,280
Sub-subtotal	15	18,140	27	47,670	27	50,510	69	116,320
Support								
Project Manager	12	17,820	12	18,500	12	19,220	36	55,540
Secretary	12	12,640	12	13,250	12	13,900	36	39,790
Clerk-typist	-	-	12	10,000	12	10,500	24	20,500
Bibliographer-Editor	6	7,000	12	15,200	12	16,400	30	38,600
Utility person	-	-	12	10,000	12	11,200	24	21,200
Student help-casuals	-	6,000	-	6,000	-	14,000	-	26,000
Sub-subtotal	30	43,460	60	72,950	60	85,220	150	201,630
Subtotal	179	228,100	249	331,340	249	356,750	673	916,190

	1978-79	1979-80	1980-81	Total
FRINGE BENEFITS	40,800	60,400	64,000	165,200
CONSULTANTS	4,000	5,000	5,000	14,000
NETWORK COSTS				
Planning Conf. (incl. travel)	10,000	---	---	10,000
Regional Conf. (incl. travel)	---	15,000	3,000	18,000
Regional Coord. Grants @$3,000	---	15,000	18,000	33,000
Cooperator Grants @$500	---	15,000	18,000	33,000
Subtotal	10,000	45,000	39,000	94,000
TRAVEL & SUBSISTENCE				
Project Personnel				
Domestic	7,000	7,700	8,400	23,100
Foreign (incl. Network Coord.)	12,000	20,000	20,000	50,000
Subtotal	19,000	27,700	28,400	75,100
PARTICIPANT COSTS	18,000	19,800	21,800	59,600
FREIGHT	---	10,000	6,000	16,000
PUBLICATIONS	3,000	6,000	6,000	15,000
EQUIPMENT & SUPPLIES				
Library & Computer	1,500	1,800	2,000	5,300
Office/Training Supplies	4,000	5,000	4,000	13,000
Agricultural Supplies	6,000	10,000	10,000	26,000
Scientific Supplies	14,000	22,000	20,000	56,000
Utilities and Lease	12,000	14,000	16,000	42,000
Office/Training Equipment	1,500	2,000	500	4,000
Agricultural Equipment	6,000	12,000	3,000	21,000
Scientific Equipment	15,000	13,000	3,000	31,000
Subtotal	60,000	79,800	58,500	198,300
SUBCONTRACT	35,250	35,790	36,880	107,920
VEHICLE LEASE	6,200	6,800	7,200	20,200
INDIRECT COSTS	73,000	106,030	114,160	293,190
TOTAL	497,350	733,660	743,690	1,974,700

Appendix D

Input/Output Budget

	INITIAL PHASE		1978-79		1979-80		1980-81		TOTAL	
	Total Thru June 1 '78		Work Mths.	Costs	Work Mths.	Costs	Work Mths.	Costs	Thru June 1, 1981	
INPUTS										
Salaries & Wages	396	372,050	175	228,100	249	331,340	249	356,750	1,069	1,288,240
Fringe Benefits		60,907		40,800		60,400		64,000		226,107
Consultants		7,886		4,000		5,000		5,000		21,886
Network Costs		-------		10,000		45,000		39,000		94,000
Travel & Subsistence		49,104		19,000		27,700		28,400		124,204
Participant Costs		47,877		18,000		19,800		21,800		107,477
Freight		-------		-------		10,000		6,000		16,000
Publications		2,880		3,000		6,000		6,000		17,880
Equipment & Supplies		192,349		60,000		79,800		58,500		390,649
Vehicle Lease		9,800		6,200		6,800		7,200		30,000
Subcontract		78,630		35,250		35,790		36,880		186,550
Indirect Costs		110,824		73,000		106,030		114,160		404,014
TOTAL COSTS BY INPUTS		932,307		497,350		733,660		743,690		2,907,007
OUTPUTS (Res. Objects.)										
1. Rhizobium collection	79	186,450	18	49,700	20	58,700	20	59,500	137	354,350
2. Selection of superior strains	59	139,850	44	124,350	62	183,400	62	185,900	227	633,500
3. Network of field testing	--	-------	14	39,800	37	110,100	50	148,740	101	298,640
4. Inoculation methodology	40	93,250	26	74,600	30	88,000	17	52,050	113	307,900
5. Legume N-contribution cropping systems	139	326,300	52	149,200	75	220,100	75	223,100	341	918,700
6. Training program	79	186,457	21	59,700	25	73,360	25	74,400	150	393,917
TOTAL COSTS BY OUTPUTS	396	932,307	175	497,350	249	733,660	249	743,690	1,069	2,907,007

141 I/953

Proj. No. 931 0613
PA- 931063
PO-AAC-403

RESEARCH PROJECT

UNIVERSITY OF HAWAII COLLEGE OF TROPICAL AGRICULTURE

CONTR-N-FIXATION-SYMBIOTIC TROP LEGUMES 30p

I. PROJECT SUMMARY

A. Title : Nitrogen Fixation by Legumes as a Major Factor for Food Production in Less Developed Countries

B. Duration : Three years with possible extension

C. Estimated Cost : $900,000.00 for three years

D. Principal Investigators :

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931-613

E. Narrative: The recent price increases for chemical nitrogen fertilizers has further restricted their usefulness for food production in many LDCs especially by small farmers. The most feasible alternative N-source is symbiotic N-fixation by legumes. Legumes must also serve an increasingly important role in providing high-protein food and feed in protein-deficient LDCs.

Most of the research on N-fixation by legumes has been done in the temperate zone, but most of the techniques are applicable to tropical environments. Tropical Rhizobium research programs are in progress at a few centers including CIAT; IITA; Cunningham Laboratory and Townsville Laboratory in Queensland; IARI and a few other sites in India; Rehovat, Israel; University of Nairobi; and University of Hawaii; with smaller programs at a few additional centers. Some work is also envisioned for ICRISAT.

This project is directed at one of the more important phases of the work proposed to be done by the International Plant Nutrition Institute recommended by the

Consultative Group on International Agricultural Research for its sponsorship. Therefore, the work done under the project will be coordinated with that undertaken by the international institute when and if it is formed to assure that there is no duplication of effort. The success of the coordination or integration of this project into the multinational institute will determine the extent of A.I.D. support before further funds are obligated and will be a major issue at the time of review by RIGC and RAC when considering whether or not this project should be extended beyond the initial three years.

This project is intended to enhance these programs and to enable additional LDCs to promote symbiotic N-fixation research and development programs by a) compiling a world collection of Rhizobium strains reputed to form effective associations with legumes under tropical conditions, b) characterizing many of these strains as to effective host range and tolerance to adverse soil conditions and distributing superior strains to agriculturists throughout the tropics, c) developing more dependable inoculation methods for use in the LDCs, d) developing cultural systems which maximally exploit the Rhizobium symbiosis as a source of N for food production, and e) training biologists from LDCs in Rhizobium research and production technology.

II. RESEARCH PURPOSE AND EXPECTED PRODUCTS

A. Purpose : The proposed research and training program is directed toward increasing food production in the tropical LDCs through greater exploitation of nitrogen fixation by legumes.

B. Objectives:

1. From a comprehensive collection of Rhizobium strains select and characterize superior strains adapted to tropical conditions for distribution to research and inoculum-production units in the tropics.

2. Develop improved techniques and cultural systems for ensuring a) dependable effective nodulation and b) maximum utilization of legume-fixed N.

3. Train researchers and inoculum-producers in the appropriate techniques and subject matter for applied research and technology in Rhizobium bacteriology.

III. RATIONALE

A. Significance of the Problem: From ancient times, the nitrogen required for the growing of food and feed has been obtained primarily from a) accretions from rainfall; b) non-symbiotic N-fixation, especially Azotobacter, Clostridium and blue-green algae; and most importantly, c) symbiotic nitrogen fixation, primarily legume-Rhizobium associations. These processes are modified by practices which release N previously accumulated in the organic matter pool, or recycle or move N from one site to another (i.e. green-leaf manuring, application of animal and human excreta, composts, etc.).

In very recent times, the availability of inexpensive fossil fuels has made possible important additional sources of fixed N which have permitted tremendous yield increases in the technologically advanced countries. However, chemical N fertilizers have usually been relatively expensive in the LDCs due to shipping costs, technological costs, and the low purchasing power of small farmers. The recent price increases in fossil energy are giving rise to drastic increases in the cost of chemical N fertilizers -- in some cases the price has quadrupled-- thus further limiting the feasibility of increasing food production by this means. However, even if tropical farmers (and countries) could afford the now-costly N fertilizers, it would be physically impossible to manufacture sufficient supplies with low fertilizer prices manufacturers had not been investing in new production facilities and are unable to meet current demand.[1]

At the same time, the supply of protein in the LDCs (only 65% of the FAO recommended intake in Southeast Asia[2]) continues to lag far behind protein requirements. Much of this requirement will have to be met by increased production of pulses and other leguminous products. Legumes must also play a very important role in increasing the production of animal protein which is even more deficient than plant protein.

1/ W. Garman of A.I.D. quoted in Forbes 113(5)29. March, 1974.
2/ FAO Production Yearbook, 1971, Vol. 25

Although the quality of legume protein is somewhat inferior to animal protein for monogastrics (more so for the rat than the human) many of the qualitative deficiencies disappear when sufficient protein is fed to maintain the individual in positive N balance[3]. The key to improved nutrition thus lies largely in the production of culinarily acceptable plant proteins and animal proteins in sufficient quantity and at low enough cost to stimulate increased consumption. Such a program must ultimately fall back on efficient legume-Rhizobium strains which can fix carbon and efficiently use that carbohydrate to fix nitrogen.

Poor nodulation and low efficiency of indigenous Rhizobium strains is a common limiting factor in increasing the yields of legumes in tropical LDCs. This is particularly noticeable in standardized tests such as those conducted by INTSOY, in which low levels of N-fixation have been noted in many cases.

There are presently very few trained legume bacteriologists in the tropics and sub-tropics,[4] and this lack of personnel is perhaps the greatest limitation governing the rate of progress which can be made in the area of N-fixation by tropical legumes. This state of affairs is due in great measure to a strong emphasis in recent years on the use of N fertilizers in the "Green Revolution" and by agencies such as A.I.D.

B. Relation to Existing Knowledge: Although legumes have historically been a major source of protein in the tropics, most of the research in legume breeding and culture has been done in temperate climates. This is particularly true of research concerning the legume-Rhizobia symbiosis. Significant research programs concerning symbiotic N-fixation in the tropics and sub-tropics are underway in Australia (especially pasture legumes), Brazil, India, Hawaii, Israel, Kenya, and more recently in CIAT in Colombia (especially with Phaseolus), and IITA in Nigeria (especially with cowpeas). Smaller programs are also underway in several other countries, and work on Cicer and Cajanus is anticipated at ICRISAT.

Relatively few collections of Rhizobia are maintained in the tropics, however[5], and little work has been done on screening strains for adaptation to the various

3/ Kies, C. and H. Fox, 1971, J. Food Sci. 36:841
4/ Personal Communication: M. Alexander, Cornell Univ. (Participant: UNEP Survey of Tropical Soil Microbiology Programs)
5/ Allen, O. N., E. Hamatova and F. A. Skinner, 1973 IBP World Catalogue of Rhizobium Collections. 282 pp.

stress factors common to the tropics, or in devising techniques which would minimize the effects of such stress factors on symbiotic N fixation.

Soil fertility seriously and frequently limits symbiotic N fixation.[6] Most important are deficiencies of P, S, and K, which exert their effect on fixation indirectly, by limiting plant growth. More direct and probably of equal importance in the humid tropics, is the effect of several pH-related factors -- acidity itself, aluminum toxicity, manganese toxicity, calcium deficiency, and molybdenum deficiency. Research, mainly on temperate legumes, indicates that the main effects of acidity and calcium deficiency are on the process of nodulation, the main effect of aluminum toxicity is on plant growth, the main effect of molybdenum deficiency is on the N_2-fixing process in the nodule, and that Mn-toxicity can limit nodulation, fixation, and plant growth to almost equal degree. However, the relative importance of these different facets of soil acidity, and their relative influence on different aspects of the symbiosis, differs from soil and between species and varieties of plant.

Tropical legumes as a group are often reputed to be more resistant to the adverse effects of soil acidity and less phosphate demanding than temperate legumes. However, the available evidence suggests that tropical legumes, like temperate legumes, are diverse in their requirements.

Adequate correction of nutritional disorders by liming and fertilization is often difficult and costly in the LDCs. Many tropical soils have inordinately high requirements for phosphate. Requirements for lime may be large, so that liming costs rise sharply with remoteness from exploitable sources, especially where transport facilities are limited. Furthermore, liming to correct acidity may create or aggravate other nutritional disorders (deficiencies of Zinc, boron, and phosphate), and this tendency appears to be most marked in soils high in sesquioxides such as the oxisols and ultisols so important in agriculture in the humid tropics.

6/ Munns, D. N. 1974, Mineral Nutrition and the Legume Symbiosis. (A review) in Dinitrogen Fixation (R. W. Hardy, Ed.), Wiley & Sons. In Press

For all the above reasons, there is justification for research which will lead to the selection and distribution of superior strains of Rhizobium which are adapted to low-lime, infertile soils and to cheaper and more effective methods of correction, such as the use of tolerant legume genotypes, improved pelleting procedures, better timing and placement of seed, inoculum and fertilizer, etc. Similarly, there is need for research which will permit the selection of legume-Rhizobium associations which are tolerant to other stress conditions such as high temperatures, root exudates, gel coatings on soil particles, etc. The distribution and employment of robust strains of Rhizobium may lead to greatly increasted symbiotic N fixation in many areas where stress conditions presently limit legume production.

The work in temperate climates and in Queensland, Australia provides a firm basis for establishing a research program designed to enhance symbiotic N-fixation in the tropics and sub-tropics.[7,8] The basic techniques are well-defined, but additional workers must be trained and additional work is needed to make superior Rhizobium cultures available to the agencies and producers who can benefit from them, and to devise improved cultural techniques suited to conditions in the LDCs.

IV. RESEARCH LINKAGES

A. Multinational: If, and when, the international plant nutrition institute is formed under CGIAR sponsorship, the closest ties between the research project and the institute will be essential. The exact nature of these ties will depend on the project leaders and on the policies and personnel of the new institute but both will be influenced by A.I.D. If the institute becomes a coordinating secretariat as some potential backers are suggesting, this project would fit neatly into the pattern. If the institute becomes a fully staffed and organized research center, then the work on this project may either be turned over to the new organization or more likely the work on the project would be more narrowly defined and efforts within the new limits intensified. The full dimensions of the problems and opportunities in Rhizobium-legume efficiency go well beyond the capability of the planned project or the largest probable scope of the proposed institute.

7/ J. M. Vincent. 1970. A Manual for the Practical Study of Root Nodule Bacteria. IBP Handbook No. 15. 164 pp.

8/ Norris, D. O. 1964. Legume Bacteriology. in Some Concepts and Methods in Sub-Tropical Research. CAB Bulletin No. 47:93-101.

B. Domestic: Training programs will be closely coordinated with Rhizobium bacteriology programs at the Universities of California Davis, Florida, Minnesota, Texas A&M, Iowa State and Ohio State, depending on the specialty for which training is needed. Also linkage will be maintained with the World Federation for Culture Collections, the ICRE-UNESCO Microbiology Program and UNEP through Professor Martin Alexander of Cornell University. Close linkage will be maintained with the 211(d) Tropical Soils Consortium and the Bench Mark Soils Project, both of which are AID-funded projects domiciled in the Department of Agronomy and Soil Science, University of Hawaii.

Certain aspects of the research on Rhizobium-soil chemistry interactions will be sub-contracted to the Department of Soils and Plant Nutrition of the University of California - Davis, in order to enlist the expertise and research support of Professors D. N. Munns and C. C. Delwiche.

Research coordination and supplemental funding for additional related research activities will also be sought through the Hawaii Institute for Tropical Agriculture.

C. Foreign: Cooperative relationships will be particularly sought at the following centers (or programs) in order to provide broad mutual support for the collection, screening and field-testing of Rhizobium strains and for evaluating cultural techniques.

	Center (or Program)	Country	Contact	Area of Specialization
1.	CIAT	Colombia	Dr. Peter Graham	Phaseolus spp.
2.	IITA	Nigeria	Dr. A. Ayanoba	Vigna spp.
3.	INTSOY	H. Q. Ill.	Dr. C. N. Hittle	Soybean
4.	IPEACS	Brazil	Dr. J. Bobereiner	Soybean & others
5.	ICRISAT	India	Dr. R. Cummings	Cicer & Cajanus spp.
6.	AVRDC	Taiwan	Dr. R. Chandler	Mung & Soybeans
7.	Jung Tsing Nat'l. Univ.	Taiwan	Prof. M. Wu	Soybean
8.	Poona Biol-N-Fix'N Scheme	India	Dr. V. P. Bhide	Peanut & others
9.	IARI	India	Dr. N. S. Subba Rao	Soil & Rhizophere Stress Factors
10.	Gadja Mada Univ.	Indonesia	Dr. Jutono	Soybean & others
11.	Rothamstad Expt. Sta.	England	Dr. P. J. Dart	Cicer & others
12.	CSIRO-Cunningham Lb.	Australia	Dr. R. A. Date	Tropical Forage Legumes
13.	AES-UPR	Puerto Rico	Dr. G. Spain	Vegetable legumes

V. PLAN TO FACILITATE UTILIZATION OF RESULTS

An annotated catalogue will be produced which will describe the Rhizobium strains in the comprehensive collection, and this will be distributed to agencies and workers throughout the tropics. As screening and selection proceeds, the catalogue will be updated at intervals to permit researchers and inoculum producers to select the strains best suited for local use. Strains of Rhizobia listed will be supplied to any appropriate agency upon request.

In cooperation with the centers, TAB, and the regional bureaus, popular-type reports and bulletins will be prepared. In addition, research results will be published in journals having wide distribution in the tropics, and scientists will be encouraged to make presentations at meetings attended by tropical biologists, agronomists, and agricultural administrators.

Trainees and graduate research assistants will be recruited from agencies which are directly involved in upgrading crop production in the LDCs, either through applied research or extension-support programs (such as seed or inoculum production and distribution.) Upon return to their posts, these people will be expected to incorporate the results produced by this project (such as selected Rhizobium strains and improved inoculation techniques) into their own programs. Consultation will be provided as needed to assist in the upgrading of current programs or in establishing new programs directed toward increasing N-fixation by legumes.

Additional utilization of results can be expected through cooperative programs with the research organizations listed in the previous section.

VI. MANAGEMENT OPERATIONS

A. Facilities: The University of Hawaii is prepared to commit space laboratory, office and a glasshouse to this project. In addition, field testing can be conducted at any of the over 20 research sites maintained by the Hawaii Agricultural Experiment Station, permitting the sampling of a wide range of soils (including the important Oxisols and Ultisols) and climatic regimes.

B. Evaluation: Evaluation of the project shall be carried out under the auspices of TA/AGR and shall be conducted annually or more often as appropriate. Criteria for evaluation may include the following:

1. Research

a. Rhizobium collection to represent a very broad base of germplasm from throughout the tropics.

b. Screening program to identify Rhizobium strains which have:

(1) superior efficiency--each major pulse and some forage-type legumes.

(2) high levels of tolerance to high soil Al and Mn, low soil Ca and Mo, high soil temperature, and other stress factors.

c. Field testing to involve at least four sites by end of second year and to include the major pulses and N-source legumes adapted to the region represented by each site.

2. Training

a. Calibre of graduate research assistants and trainees recruited.

b. Increase in understanding of microbiological and agronomic principles, and improvement in appropriate skills by R. A.'s and trainees.

c. Success attained by R. A.'s and trainees in using their training and the results of the project to upgrade programs upon returning to their countries.

3. Utilization

a. The number of tropical LDCs where the superior strains thus selected to become the basis for expanded legume-inoculant programs.

b. Acceptance by tropical producers of project-developed techniques for inoculation of legume and for exploiting legume fixed N.

C. Rationale for Selection of University of Hawaii as Contractor:

The Hawaii Agricultural Experiment Station has an extensive background in the areas of tropical crops and soils. Of particular relevance is the expertise represented in the management of tropical soils which are often acid and have a high P-fixing capacity. There is also considerable competence in the area of tropical legume culture--particularly forage legumes and vegetable legumes. An active program of soil microbiology is also underway with research focusing on soil pH effects on legume N fixation as well as other topics.

A listing of the staff of the Department of Agronomy and Soil Science is included as Attachment A.

Research sites are available year-round for field testing of legume and soil x Rhizobium interactions under a wide range of soil and climatic conditions. Daylength effects do not differ greatly from the conditions prevailing in most tropical LDCs: an important factor in crops such as soybeans.

Hawaii also enjoys a good exchange of information and personnel with many tropical areas--particularly in Asia and the Pacific--due its "crossroads" location and the large number of graduates working in the tropics.

VII. RESEARCH DESIGN AND METHODS

A. Plan of Work

ITEM	EXPECTED MONTH TO START	EXPECTED MONTH TO COMPLETE
1. Survey existing work on N-fixation by tropical legumes and on tropical Rhizobia by means of questionnaires and visits to research centers and international conferences. Write review of work in progress.	0	8
2. Recruit graduate research assistants. Conclude working agreements with tropical research centers for Rhizobia and legume-nodule collection and for on-site field trials.	0	6
3. Employ the internationally known consultants for 2-4 week periods to assist in developing efficient training and research procedures, syllabi, etc.	4	5
4. Collect strains of Rhizobia, both from existing collections and new isolates from nodules, which are reputed to form effective associations with tropical legumes in the tropics. Establish a computerized cataloguing system.	0	Continuous

5.	Graduate training: Two research fellows	6	36
6.	Test library strains of Rhizobia for host range using selected legumes in the greenhouse.	6	24
7.	Screen selected strains of Rhizobia for tolerance to:		
	a. high soil temperatures (laboratory, greenhouse)	9	18
	b. high levels of Al and Mn (greenhouse, field)	9	30
	c. low levels of Ca and Mo (greenhouse, field)	9	30
8.	Circulate first annotated catalogue of the tropical Rhizobium collection.	12	
9.	Employ two internationally-known consultants to review the program, assist in the training program, and to recommend program improvements.	12	14
10.	Conduct first 6-week training program for six trainees from LDCs.	12	13
11.	Convene an international conference in Hawaii on the topic of Nitrogen Fixation by Tropical Legumes.	13	14
12.	Conduct second 6-week training program for six trainees.	14	16
13.	Graduate training: Two additional graduate R. A.'s.	12	36
14.	On-site field trials at Cooperating Institutions	15	36
15.	Studies of inoculation techniques and techniques for extending culture life.	15	36
16.	Studies on utilizing legumes as a source of N for non-leguminous crops.	18	36
17.	Conduct third and fourth 6-week training programs for 6 trainees each session.	33	36

B. Procedures--Each Objective

1. Assemble, screen, and field-evaluate a comprehensive collection of tropical-legume Rhizobium strains.

a. Survey the status of Rhizobium research presently being conducted in the tropics, or on legume-Rhizobium associations important to the tropics.

This survey will be carried out by means of both questionnaires and visits to research centers. At the same time liaisons and cooperative working arrangements will be established with workers in the tropics. Such arrangements will be especially sought with the centers and programs detailed in Section IV.

A status report will be prepared in the first year to serve as a guideline for developing detailed testing and training plans.

b. Establish a comprehensive collection ("Bank") of Rhizobium strains reputed to form symbiotic associations with tropical legumes.

This collection will be based on bacteria obtained from two general sources. Initially cultures will be solicited from existing collections with emphasis on Rhizobium of the cowpea-type as well as those which are specific for the major pulses and N-source legumes common to the tropics. This foundation will then be extended by isolating strains from legume nodules supplied by cooperating workers throughout the tropics. Bacteria isolated from such nodules will be tested against Phaseolus lathyroides (due to its unusual promiscuity) or the host from which the nodules were collected. The presence of nodules, no matter how slight, confirms that bacteria as a Rhizobium. Standard procedures will be used in the isolation and maintenance of Rhizobium strains from nodules, but these will be modified as needed for special situations. For example, where fresh nodules are obtainable, special precautions will be necessary to assure the isolation of the desired Rhizobium from old or dessicated nodules in the presence of numerous contaminants--including secondary Rhizobium strains.

c. Determine the host range and relative N-fixing efficiency of Rhizobium strains.

Preliminary assessment of the ability of a particular Rhizobium to nodulate specific legumes and of the capacity of this symbiosis to fix nitrogen will be evaluated first on agar slopes or in modified "Leonard" jars in the greenhouse, using special precautions to prevent cross contamination by air-borne or droplet-borne Rhizobium.

The effectiveness of Rhizobium strains for symbiotic N-fixation will be assessed initially by determining the N yield of the inoculated plant. Once the correlations between plant yield and total nitrogen have been established for different legume species and environmental conditions, the dry weight method of evaluation is expected to be adequate for further greenhouse and field studies.

All Rhizobium strains found to be effective in fixing N with one or more legumes, or reputed to be effective elsewhere, will be catalogued and maintained in long-term storage. Storage procedures will be based on freeze drying (lyophylization) or a similar method to provide for minimal mutation in storage yet easy accessibility for further testing or distribution to workers elsewhere in the tropics.

d. Characterize selected Rhizobium cultures with respect to environmental requirements.

A broad spectrum of Rhizobium strains from the collection described above will be selected to represent the more efficient strains for each of the major tropical pulses and N-source legumes. It is estimated that 15-25% of the collected strains will be chosen for testing.

The selected strains will be characterized as to their tolerance to the following stress factors which are commonplace in the tropics:

(1) high levels of soil Al and Mn
(2) low levels of soil Ca and Mo
(3) high soil temperatures

As time permits the selected strains will also be tested for ability to nodulate and fix N in the presence of soil NO_3 and for tolerance to high osmotic pressure.

Initially, some of the rapid screening trials will be conducted in the greenhouse. Verification tests and more intensive testing of specific factors and interactions will also be conducted in the field starting shortly thereafter. Growth chamber experiments will be used to define in more detail the effects of factors which are governed or modified by aerial environment.

The continuous function type of design[2/] promises special advantages as the basis of a screening program and is suited to both field and greenhouse studies. The procedure is to establish replicate blocks in each of which there is a continuous gradient in the experimental variable, such as soil pH, temperature, or nutrient level. Precise comparison of any number of legume and/or Rhizobium genotypes is then readily done by aligning them side by side along the gradient. One such trial on a high-Mn soil in Hawaii is presently showing response to a lime gradient, including a differential tolerance of soybean varieties to Mn-toxicity and a differential response between lines of Leucaana leucocephala to overliming, as well as several large differences in response to lime levels between genera and species.

For the preliminary screening of Rhizobium strains in the greenhouse a scaled down modification of the continuous function field trial will be employed. Soil temperature effects will also be studied using the continuous function design in connection with a large temperature-gradient bar.

In addition, controlled greenhouse experiments will be conducted as needed to clarify particular issues, such as the effects of different aspects of soil acidity. Conventional statistical designs and culture-solution methods will be used for these kinds of experiments.

Field-testing at several sites will be initiated immediately upon conclusion of the first screening trials in the greenhouse, and will be used to verify the greenhouse data, and to evaluate the influence of various factors under the complex ecological conditions of the field. For many of these tests, the continuous function design will be employed, and the results plotted against the variable(s) being evaluated. Regression techniques will then permit the detection of significant differences among response curves.

2/ Fox, R. L. 1973. Agron. J. 65:454

Responses in most of the field experiments will be defined in terms of acetylene reduction capacity of the fresh nodules as well as by plant yield. For certain critical comparisons, acetylene reduction by intact root systems will also be measured.

On the basis of these trials, profiles of each tested strain will be developed, showing effective host range, N-fixing efficiency in association with specific legumes, tolerance to a range of stress factors, etc. This will provide a basis for selecting superior strains for specific legumes and specific environments. These strains will be sent to cooperating institutions as soon as feasible for additional field tests under a range of conditions representing most of the tropics.

The profiles will be catalogued on computer tape to permit periodic updating and easy retrieval. The updated results will be published at regular intervals as an annotated catalogue, using offset printing of computer-printed tables, and distributed to workers throughout the tropics.

2. Develop improved cultural practices to enhance nodulation and utilization of legume-fixed N.

a. Identify and refine inoculation procedures suited to the poor storage conditions and legume-establishment stresses encountered on small farms in the tropics.

A variety of procedures for storing inocula and inoculated seed, and for pre-plant inoculation, will be compared with standard procedures. Emphasis will be placed on pelleting and tableting of seeds with inoculum plus other substances which would be expected to 1) increase storage life, 2) protect the inoculum against competing organisms or toxic chemicals, 3) supply needed nutrients, and/or 4) stimulate infection of root hairs. The use of readily available material (such as milk, blood, common byproducts, etc. and simple or standard-item equipment will be given priority.

The initial testing of inoculants and inoculation procedures will be conducted in the greenhouse using a range of legume hosts, soils, and environmental conditions. The most promising materials and techniques will then be tested in field trials at several locations in Hawaii and at participating institutions. Tests will be conducted at different seasons to further evaluate the suitability of the test procedures over a wide range of conditions. Recovery of the Rhizobium strains used for inoculating the legumes will be assessed through serotyping procedures.

b. Develop improved legume-culture systems to maximally exploit legume N-fixation for food production.

Both perennial and annual legumes which have very high capacities for carbon (and nitrogen) fixation, yet are tolerant to marginal soil and water conditions, will be evaluated as sources of N for non-legumes. Initially, shrubby legumes, such as Leucaena leucocephala, will be compared to vine legumes (such as Dolichos lablab or Glycine javanica). Both interplanting and catch cropping systems and combinations of the two will be evaluated in terms of 1) N-yield, 2) N recoverable in the non-legume, and 3) timing of N release in relation to N demand of the non-legume.

VIII. TECHNICAL REVIEW

A. Rhizobium strains for tropical legumes and their N-fixing effectiveness.

The IBP World Catalogue of Rhizobium Collections (Allen and Hamatova, 1973) lists collections of Rhizobium in the following tropical countries: Brazil (2 collections with 11 and 16 strains), India (4 collections with 34, 13, 66 and 164 strains), Papua/New Guinea (160 strains), Tanzania (14 strains) and the U.A.R. (2 collections, 5 and 53 strains) Undoubtedly there are some other tropical collections which were not listed and some of the temperate-country collections (e.g., the C.S.I.R.O. collection at Cunningham Laboratory, Queensland and the Rothamstad collection) contain bacteria which are effective on tropical legumes. Relatively new collections now exist at CIAT and IITA also.

However, it is clear that the collection and maintenance of Rhizobium germplasm in the tropics is at a very low level of activity, and the production of inoculum for use by producers is the exception to the rule.

A large body of literature indicates the great variation in N-fixing effectiveness which exists among Rhizobium strains in association with a specific host legume, and illustrates the large increases in N-yields that can be obtained by selection of superior Rhizobium strains (e.g. Norris, 1964). A great deal of work on selection of strains suited for tropical forage legumes was done by the Dr. R. O. Norris of the C.S.I.R.O. Cunningham Laboratory in Queensland and his collection has undergirded much of the increased utilization of pasture legumes throughout the tropics.

Some of the pulses and leguminous oil seeds which are important in the tropics are also widely used in temperate countries. Strains of effective Rhizobia have been identified for these legumes and are included in a number of the collections maintained in the U.S.A. and Europe. The strains which have thus been selected, however, need to be evaluated as to their suitability for legume genotypes in use in the tropics and for tropical soils and environments. Also, they are presently scattered among numerous collections, making comparisons among strains, and the assembly of strains for field testing quite difficult for the average tropical researcher.

B. Tolerance of Rhizobium strains to acid soils and low nutrient levels.

Munns (1974) has reviewed the literature concerning the effects of soil acidity and nutrient levels on the legume-Rhizobium symbiosis, and the main conclusions were presented in Section III-B. A number of researchers have reported success in selecting strains of Rhizobium which are tolerant to acid conditions (e.g. with soybeans; Franco and Dobereiner, 1971; and with Leucaena leucocephala, Norris, 1973). However, much additional work is needed to identify strains suited for more of the major tropical legumes, and to define such tolerances in terms of levels of Al, Mn, Ca, and Mo, so that superior strains can be recommended for a wide range of conditions.

In many cases, the effects of acidity and low Ca and Mo levels can be overcome by pelleting procedures which create a favorable zone around the seed for Rhizobium growth and infection. However the interactions of Rhizobium strains with pelleting procedures have received little study in the case of tropical legumes, except for pellet-pH effects on some species (summarized by Norris, 1966) and limited work with forage-type legumes (e.g. Norris, 1971). Addition of small quantities of Mo to the pellet has been beneficial for peas (Iswaran, Rao and Sen, 1971) and this technique may be useful for other legumes as well.

C. Tolerance of Rhizobium strains to soil physical stresses.

1. Temperature

Soil temperature frequently limits the activity and persistence of Rhizobia in the tropics since survival of many strains of Rhizobia is greatly reduced at 40C (Bowen & Kennedy, 1969). There is, however, a wide variation among strains with respect to high temperature tolerance (Guss & Dobereiner, 1972), and the effects of high temperatures can be overcome by practices which favor high populations of the introduced rhizobium, such as pelleting (Souto & Dobereiner, 1970; Brockwell & Phillips, 1970).

2. Osmotic Pressure

The effects of moisture stress and salinity appear to be similar (Sprent, 1972a & b, and Subba Rao et. al. 1972) in that nodulation is inhibited by both moisture stress and salinity. N-fixation by established nodules is also depressed by moisture stress or salinity, but quickly recovers when the stress is relieved--unless the stress is sufficient to cause sloughing of the nodule. Selection of strains which are resistant to salinity stress has been reported for Sesbania cannabina (Bhardwaj, 1972), and this may be a useful means of selecting strains for other legumes which are grown on saline or droughty soils in the tropics. Pelleting has also proved beneficial for Phaseolus aureus in a saline soil (Chhonka, Iswaran, Jauhri, 1971). However, the fact that such stress operates mainly on nodulation indicates that the main effect may be more on the infectivity of the root hair than on the Rhizobium.

D. Procedures for enhancing nodulation.

As mentioned in the preceding section, pelleting of legume seeds increased the nodulation and N-yields of various leguminous species under a variety of stress conditions, including acid soils, high soil temperature, dry or saline soil, and Mo-deficient soils. Pelleting also improves the storage characteristics of inoculated seed, permitting seed to be sown several weeks after inoculation.

The pellet usually incorporates a layer of inoculum mixed with a sticker next to the seed, and then coated with one more layer of finely-ground lime, rock phosphate or calcium silicate (Plucknett, 1971). The choice of coating material depends on whether the Rhizobium strain is acid producing or alkaline producing (Norris, 1966).

E. Legumes as an N-source for N-legumes.

The literature on green-manuring and green-leaf manuring is extensive, especially from India and Indonesia (Calma and Whitney, 1960 a & b). Intercropping of legumes and non-legumes has been extensively practiced in India and elsewhere, but critical studies of this practice are few. Tropical pasture-type legume-grass mixtures have been shown to be much more productive than grasses alone (e.g. Whitney, Kanehiro and Sherman, 1967) with the legume component contributing in excess of 300 pounds of N/A/yr. to the mixture. Transfer of N from legume to grass was low, however, (Whitney and Kanehiro, 1967), indicating that incorporation of the vegetative portion of the legume (i.e. by green manuring or by trampling in pastures) would be necessary for release of sufficient N to support vigorous growth by a non-legume. Interplanting of several legumes with corn has been reported by Agboola and Fayemi (1970, 1972). Corn yields were quite low when no nitrogen fertilizer was applied, except in the case of intercrop Phaseolus aureus. There were no residual effects of the legume-fixed

N in the field (the vegetative portions were removed), but pot tests indicated a small residual N effect of about 30 kg N/ha.

The use of fast-growing shrubby legumes as an N-source for non-legumes has been promoted heavily in India, using primarily Sesbania spp. These undoubtedly make a significant contribution where intensively used. Recent selections of Leucaena leucocephala which are extremely vigorous and fast growing (Brewbaker, Plucknett and Gonzalez, 1972) provide an attractive alternative since yields of up to 40 tons per acre of green foliage containing about 700 pounds of N have been recorded, and even higher yields are possible. Intercropping systems using this legume as an N-source are presently being studied in Hawaii.

There is a clear potential for the increased use of legumes solely as an N-source. However, systems using this approach require a) high-yielding legumes, and b) some compromises regarding the utilization of water or solar radiation inputs for crop production. Research is thus needed to build the greatest possible efficiency into legume/non-legume systems in order to minimize these compromises and thereby maximize yields.

IX. ESTIMATED BUDGET

Nitrogen Fixation by Legumes as a Major
Factor for Food Production in
Less Developed Countries

Expense Category	Year		
	First	Second	Third
Salaries (Man-months)	$ 74,000 (72)	$155,000 (150)	$165,000 (150)
Consultants	3,800	2,400	0
Fringe Benefits (20% of Salaries)	14,000	31,000	33,000
Overhead (46.62% of Salaries)	34,499	72,261	76,923
Travel and Transportation	17,620	25,130	29,790
Allowances (Trainees')	0	9,600	12,200
Other Direct Costs	32,500	22,800	6,100
Equipment, Vehicles and Supplies	56,400	13,900	15,800
Training (Staff)	0	0	0
Subcontracts	20,500	20,900	21,400
Annual Totals	$253,319	$357,991	$360,213

2 57
3 58
360
97

X. GENERAL APPRAISAL

This proposal grew out of the need to help LDCs with their nitrogen fertilizer sources in relation to rising fertilizer costs, fertilizer shortages, and demands for increased food supplies.

A. Initial Proposal

In the early spring of 1974, an informal proposal on nitrogen fixation by legumes was received from the University of Hawaii. No action was taken at that time as TA/AGR wanted to become more knowledgeable on the opportunities and needs in this area.

B. Research Area Review

On April 26, 1974, a small group of highly qualified microbiologists met with TA/AGR to exchange suggestions as to how biological fixed nitrogen might be used to alleviate LDC nitrogen fertilizer problems. A representative of the University of Hawaii was present but the Hawaii proposal was not discussed. Attachment B lists the participants who attended. The group was of the consensus that symbiotic nitrogen fixation offers the greatest hope for immediate payoff. Training of LDC scientists was listed as a first priority. Secure banks of organisms, better characterizing of the tropical Rhizobia, and the collection and selection of more efficient strains and matching cultivars, were suggested as high priority needs.

At a meeting of the International Symposium on Nitrogen Fixation, June 3-8, 1974, Pullman, Washington, some of the same groups of above specialists were present. This afforded an opportunity for TA/AGR to discuss this problem further with them and with others attending the symposium.

C. A.I.D. Internal Review

On the basis of the several discussions, TA/AGR requested the University of Hawaii to modify their earlier proposal. This revised formal proposal was received by TA/AGR on July 6, 1974.

1. There is a collection at Beltsville. How would this relate to proposed project?

2. What is the relationship to CIAT and IITA expanded programs?

3. Linkages with national and international programs need to be better documented?

4. The principal investigators need to try for more quantitative statements, research goals, target number of strains, profiles, and yield gains.

5. Concern over the estimated equipment costs was expressed. Further justification will be needed.

6. Emphasis should be placed on crops in the traditional farming cycle, especially food crops, rather than pastures and forages. Crops that have been identified for early consideration are listed in Attachment C.

7. The estimated cost in the proposal is probably in excess of funds available to A.I.D.

8. The relationship to the proposed GTZ project on "World Rhizobium Collection and Study Center needs to be clarified. If both were approved, there could be some duplication of effort.

The project was presented to the RIGC for review on August 15, 1974 when it was discussed in depth. The major concern was that in the development of new projects in soils and plant nutrition there appeared to be serious possibilities of duplication of effort and inefficient use of A.I.D. resources. Following a lively exchange the following motion was passed unanimously:.

> RIGC recommends that this research proposal be approved for forwarding to RAC on the premises (1) that the research work will be firmly coordinated with, and to the extent possible, fully integrated with the operations of the international plant nutrition institute, when and if the institute is formed; (2) that the Regional Bureaus of A.I.D. will be consulted in this regard at the appropriate time: and (3) that appropriate language be inserted in the project statement for RIGC approval.

The ameadments to the project statement have been made in accordance with the conditions of the RIGC approval and have been cleared with each of the Regional Bureaus. Close liaison with the principal investigators will be maintained to assure that the project is fully responsive to the needs of the field program.

As pointed out under internal review, the budget is somewhat higher than the funds available and further sharpening of the work plan will be necessary when the final contract is negotiated. This would be desirable in any case since the plan as presented clearly exceeds the capability of the limited staff unless the project were to be continued to infinity.

D. <u>Recommendation</u>

Following review of the subject matter of the research, seeking more effective use of the legume-Rhizobium symbiosis, and the specific research proposal, this project is strongly recommended by TA/AGR to the RAC for approval.

REFERENCES

Agboola, A. A. and A. A. A. Fayemi. 1970. Interplanting of maize with legumes. II. The effects of phosphorous and intercropping of tropical legumes on yields of maize. W. Afr. J. Biol. Appl. Chem. 13:31-38.

Agboola, A. A. and A. A. A. Fayemi. 1972. Fixation and excretion of nitrogen by tropical legumes. Agron. J. 64:409-412.

Allen, O. N. and E. Hamatova. 1973. IBP World Catalogue of Rhizobium Collections. (F. A. Skinner, Ed.) Knapp, Drewett & Sons Ltd., Great Britain. 282 pp.

Bhardwaj, K. K. R. 1972. Note on the growth of Rhizobium strains of dhaincha (Sesbania cannabina Retz.) Pers.) in a saline-alkali soil. Ind. J. Agri. Sci. 42:432-433.

Bowen, G. D. and M. M. Kennedy. 1959. Effect of high soil temperatures on Rhizobium spp. Queensland J. Agr. Sci. 18: 161-170.

Brewbaker, J. L., D. L. Plucknett, and V. Gonzalez. 1972. Varietal variation and yield trials of Leucaena leucocephala (koa haole) in Hawaii. Hawaii Agr. Exp. Stn. Bull. 166.

Brockwell, J. and L. J. Phillips. 1970. Studies on seed pelleting as an aid to legume seed inoculation. 3. Survival of Rhizobium applied to seed sown into hot dry soil. Austr. J. Exp. Agric. Anim. Husb. 10:739-744.

Calma, V. C. and A. S. Whitney. 1960a. A survey of the culture and utilization of some tropical cultivated legumes in different countries. Univ. Phil. College of Agr. Mimeo.

Calma, V. C. and A. S. Whitney, 1960b. Abstract Bibliography: Legumes and green manuring in relation to production of annual crops under tropical conditions. U. P. College of Agric. Mimeo.

Chhonka, P. K., V. Iswaran, and K. S. Jauhri. 1971. Seed pelleting in relation to nodulation and nitrogen fixation by Phaseolus aureus L. in a saline alkali soil. Pl. Soil 35:449-452.

Franco, A. A. and J. Dobereiner. 1971. Manganese toxicity in an acid soil affecting the soybean--Rhizobium symbiosis. Pesq. Agropec. Bras. 6:57-66.

Guss, A. and J. Dobereiner. 1972. Effect of nitrogen fertilization and soil temperature on nitrogen fixation in Phaseolus vulgaris. Pesq. Agropec. Bras. 7:87-92.

Iswaran, V., A. V. Rao and A. Sen. 1971. Effect of sodium mobybdate with inoculant on the yield of pea crop. Zentr. Bakt. 126:778-779.

Hanson, D. H. 1974. Mineral nutrition and the legume symbiosis. In Dinitrogen Fixation (R. W. Hardy, ed.), Wiley & Sons. In Press.

Norris, D. O. 1964. Legume Bacteriology. In Some Concepts and Methods in Sub-tropical Pasture Research. CAB Bull. 47. pp. 104-117 (See p. 111).

Norris, D. O. 1966. The Legumes and their Associated Rhizobium. In Tropical Pastures (W. Davies and C. L. Skirner, ed.) Faber & Faber Ltd. London. pp. 89-105 (See p. 104).

Norris, D. O. 1971. Seed pelleting to improve nodulation of tropical and sub-tropical legumes. 3. A field evaluation of inoculant survival under lime and rock phosphate pellet on Dolichos lablab. Aust. J. Exp. Agr. Anim. Husb. 11:667-683.

Norris, D. O. 1973. Seed pelleting to improve nodulation of tropical and sub-tropical legumes. 5. The contracting response to lime pelleting of two Rhizobium strains on Leucaena leucocephala. Aust. J. Expt. Agric. Anim. Husb. 13:98-101.

Plucknett, D. L. 1971. Use of pelleted seed in crop and pasture establishment. Univ. Hawaii Coop. Ext. Serv. Circular 446.

Sprent, J. I. 1972a. The effects of water stress on nitrogen-fixing root nodules. IV. Effects on whole plants of Vicia faba and Glycine max. New Phytol. 71:603-611.

Sprent, J. I. 1972b. The effects of water stress on nitrogen-fixing root nodules. III. Effects of osmotically applied stress. New Phytol. 71:451-460.

Souto, S. M. and J. Dobereiner. 1970. Soil temperature effects on nitrogen fixation and growth of Stylosanthes gracilis and Pueraria javanica. Pesq. Agropec. 5:

Subba Rao, N. S., M. Laksmi-Kumari, C. S. Singh, and S. P. Magu. 1972. Nodulation of lucerne (Medicago sativa) under the influence of sodium chloride. Ind. J. Agric. Sci. 42:384-386.

Whitney, A. S., Y. Kanehiro, and G. D. Sherman. 1967. Nitrogen relationships of three tropical legumes in pure stands and in grass mixtures. Agron. J. 59: 47-50.

Whitney, A. S. and Y. Kanehiro. 1967. Pathways of nitrogen transfer in some tropical legume-grass associations. Agron. J. 59:585-588.

FACULTY MEMBERS

DEPARTMENT OF AGRONOMY AND SOIL SCIENCE

Duane P. Bartholomew	Crop Physiology, Plant Nutrition
Richard Bullock	Tree Physiology
Ramon de la Pena	Root Crop Production, Crop Physiology
Paul C. Ekern, Jr.	Soil Management, Physics
Samir El-Swaify	Soil Physics, Irrigation
Robert L. Fox	Soil Fertility, Crop Management
Richard E. Green	Herbicides, Soil Physics
Haruyoshi Ikawa	Soil Mineralogy
Rollin C. Jones	Soil Mineralogy, Characterization
Yoshinori Kanehiro	Soil Chemistry, Fertility
Burton Koch	Soil Microbiology
Dennis Matsuyama	Research Associate
Wade W. McCall	Soil Management
Donald Plucknett	Crop Management, Weed Control
Peter P. Rotar	Plant Breeding, Cytogenetics
Wallace G. Sanford	Plant Nutrition, Physiology
James A. Silva	Soil Fertility, Soil Chemistry
Leslie D. Swindale	Soil Genesis & Classification
Yusuf N. Tamimi	Soil Fertility, Forest Soils
John R. Thompson	Crop Production
Goro Uehara	Soil Physics, Mineralogy, Water Science
Ukio Urata	Plant Breeding
Roger T. Watanabe	Soil Testing
A. Sheldon Whitney	Pasture Management, Legume Ecology
Ronald Yoder	Research Associate
Hong Yip Young	Plant Nutrition, Chemistry

ATTACHMENT B

NAMES OF MICROBIOLOGISTS MEETING WITH EA/AGR on April [illegible], 1[illegible]

Dr. Martin Alexander, Cornell University

Dr. Robert Burris, University of Wisconsin

Dr. Harold J. Evans, Oregon State University

Dr. Lloyd R. Fredrick, Iowa State University

Dr. Ralph F. W. Hardy, E. I. Dupont

Dr. Charles Sloger, ARS, USDA

Dr. Dean F. Weber, ARS, USDA

Dr. Sheldon Whitney, University of Hawaii

Dr. Frank G. Viets, ARS, USDA, Fort Collins, Colorado

APPENDIX 4

Major Food Grain Legumes grown in the Tropics and Subtropics

I. Grown for protein foods

1. Beans -- Phaseolus vulgaris. Prefers moderate rainfall, well-drained, fertile soils.

2. Field and Garden Peas -- Pisum arvense. Prefers cooler growing season, moderate rainfall, neutral well-drained soils, medium fertility.

3. Cowpeas -- Vigna unguiculata. Prefers tropical humid climate, tolerates acid soils if well-drained, responds to fertility.

4. Chickpeas -- Cicer arietinum. Prefers cooler growing season, moderate rainfall, medium texture, well-drained soils.

5. Lentils -- Lens culinaris (L. esculenta). Prefers cooler growing season, moderate rainfall, well-drained soils of medium texture.

6. Pigeon peas -- Cajanus cajan. Tolerates some drought on deep soils, prefers well-drained fertile soils.

7. Mung beans -- Vigna radiatus. Adapted to ward humid regions, prefers fairly deep, well-drained soils.

8. Broad beans -- Vicia faba. Prefers cooler growing season, moderate rainfall, well-drained soils, tolerates some soil salinity.

II. Grown for oil and protein

9. Groundnuts -- Arachis hypogaea. Prefers moderate rainfall, and dry weather when ripening, well-drained, sandy loams.

10. Soybeans -- Glycine max. Prefers climatic conditions similar to those for maize, well-drained, fertile soils.

Note: Within each of these species there are many varieties that may differ widely in growth habits, and adaptation to soil and climatic conditions. Growers are advised to select varieties that have been locally tested and found to be productive. For regions of limited rainfall, the varieties with short growing periods are more likely to mature seed before soil moisture is exhausted.

The growing of one of these crops will normally increase the residual soil nitrogen by 40 or more lbs. per acre (44 kg/ha), for the benefit of the following crop.

B. Minor Food Grain Legumes for the Tropics and Subtropics.

Each of the following species is quite important as a food crop in certain regions of the tropics and subtropics, although their production is not as widespread as the major food grain legumes. Within each species there are many varieties, differing markedly in plant type, resistance to local pests, in adaptation to soil and climatic conditions and in yielding capacity. There appear to be substantial opportunities for markedly increasing yields of all of these crops.

Common Name	Botanical Name
1. Horsegram	1. Dolichos biflorus (D. uniflorus)
2. Lablab (hyacinth bean, bonarista bean)	2. Dolichos lablab, Lablab niger.
3. Jack bean	3. Cararalia ensiformis
4. Cluster bean (quar)	4. Cyamopsis telra gonolobus (C. psoralioides)
5. Grass pea	5. Lothyrus satirus
6. White sweet lupine	6. Lupine albus
7. Yam bean	7. Pachyrrigus erosus (only tubers for food; seeds are toxic)
8. Tepary bean	8. Phaseolus acutifolius
9. Lima bean	9. Phaseolus lunatus
10. Scarlet runner bean	10. Phaseolus multiflorus
11. Adzuki bean	11. Vigna angularis
12. Rice bean, moth bean	12. Vigna calcaratus, V. aconitiflolius
13. Catjang bean	13. Vigna unguiculata (V. cylindrical)
14. Yardlong bean	14. Vigna unguiculata (V. sesquipedalis)
15. Bambarra nut	15. Voandzeia subterranea

The choice of a crop species suited to local soils and climate, plus the planting of the particular varieties that have proven to be high yielding in the region, and the effective use of cultural practices and necessary fertilizers, will normally increase yields very substantially.

The growing of one of these crops will normally increase the residual soil nitrogen by 40 or more lbs. per acre (44 kg/ha) for the benefit of the following crop.

C. Legume Green Manure Crops for the Tropics and Subtropics.

The following legume species has been reported as successful green manure species for the tropics and subtropics. When effectively inoculated with nodule-forming bacteria, the residual nitrogen derived from growing the green manure crop, may range from 40 to 100 lbs. per acre (44-110 kg/ha), depending on the vigor of the green manure crop, and the length of the growth period.

The following species are palatable and nontoxic to livestock, and may be grazed after full growth is made, without serious reduction in nitrogen contributions.

Common Name	Botanical Name
1. Alyce Clover	1. Alysicarpus vaginalis
2. Cassia species	2. C. ferruginea, C. pumila
3. Crotalaria species	3. C. intermedia, C. lanceolata
4. Guar	4. Cyamopsis tetragonoloba (C. psoralioides)
5. Lablab	5. Dolichos lablab, D. uniflorus
6. Hairy indigo	6. Indigofera hirsutus
7. Vetchling	7. Lathyrus hirsutus, L. sotivus
8. Lupines	8. Lupinus angustifolius (sweet type) Lupinus lutena (sweet type)
9. Serradella	9. Ornithopus sativus
10. Sesbania	10. Sesbania aculeata, S. exaltata
11. Velvet bean	11. Stizolobium deeringianum
12. Beerseem	12. Trifolium Alexandrinum
13. Fenugreek	13. Trigonella foenum-graecum
14. Cowpeas, forage type	14. Vigna unguiculata (V. sinensis)
15. Mungbean, forage type	15. Vigna radiatus (V. aurens, V. mungo)

Within each of these species there are many varieties that may differ widely in growth habits, and in adaptation to soil and climatic conditions. Growers are advised to select varieties that have been field tested under local conditions and found to be high yielding and resistant to insect pests and diseases.

D. Major Forage Legumes for Improved Grazing Lands and Forage Harvest in the Tropics and Subtropics.

Common Name	Botanical Name
1. Calopo	1. Calopogonium mucunoides
2. Centro	2. Centrosema pubescens
3. Dwarf Koa	3. Desmanthus Virgatus
4. Green leaf desmodium	4. Desmodium intortum
5. Silverleaf desmodium	5. Desmodium uncinatum
6. Lablab	6. Dolichos lablab
7. Glycine	7. Glycine wightii (G. javanica)
8. Leucaena	8. Leucaena Leucocephala
9. Lotononis	9. Lotononis bainesii
10. Lucerne (alfalfa)	10. Medicago sativa
11. Siratro	11. Phaseolus atropurpureus
12. Phaseybean	12. Phaseolus lathyroides
13. Puero (kudzu)	13. Pueroria phaseoloides
14. Stylo (Brazilian lucerne)	14. Stylosanthes gracilis
15. Townsville lucerne	15. Stylosanthes humilis

These legume species are perennials (except No. 15 is a reseeding annual) that are productive when effectively inoculated with nodule-forming bacteria. They are rich in protein and highly nutritious to livestock. They are usually grown in mixture with compatible forage grasses.

These legumes are strong nitrogen fixers; records of 200 to 500 lbs. per acre (220-550 kg/ha) of residual soil nitrogen per year have been reported. Such contributions to soil nitrogen are highly important when a seeding of forage legumes is made as part of a crop rotation to maintain soil productivity.

There are distinct varieties of each of these species. Growers are advised to plant those varieties that have been field tested and found to be well adapted to local soil and climatic conditions.

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PROJECT REVIEW SUMMARY

4/9 4/29 5/29

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PD-AAP-403
bp

PROJECT TITLE: Nitrogen Fixation-Symbiotic Tropical Legumes

DATE OF REVIEW: 3/18/80

PROJECT NO.: 931-0613

DSB OFFICE/DIV.: Tropical Soil and Water Management

List actions to be taken (or issues to be resolved) as a result of Project Review Meeting	Action Officer	Date Action to be Completed
1. Prepare scope of work for team evaluation and review in July, 1980 to make recommendations regarding the extension of the project through 1984.	L.R. Frederick	Mar.31, 1980
2. Prepare proposal for extension of project until 1984.	J.Halliday U.Hawaii	Aug.31, 1980
3. Team evaluation of project	L.R.Frederick	Jul.31, 1980
4. PIO/T -final increment of funding for current approved contract	L.R.Frederick	Mar. 20, 198

Lloyd R. Frederick
Project Manager

/s/
Keith Byergo
Office Director

Clearance: DS/AGR, MMozynski

Attachments: ABS Project Data Sheet
Project Review Information Sheet
Other

Distribution: Project Files
DS/DAA
DS/RD Program Analyst

PROJECT REVIEW INFORMATION

PROJECT TITLE Nitrogen Fixation-Symbiotic Tropical Legumes

DATE OF REVIEW 3/18/80

PROJECT NO. 931-0613

I. Briefly state principal subject(s) to be discussed during the review.
The adequacy of the germ plasm resources for root nodule bacteria (rhizobia), the evaluation of the rhizobia on tropical legumes, the development of biological nitrogen technology for legumes in the tropics, the initiation of the International Network of Legume Inoculation Trials with scientists in developing countries to determine the benefit of inoculation on specific crops, the training of BNF scientists and technicians.

II. Please respond to the following questions. Additional detail can be given below if warranted or necessary.

a. Is project implementation on schedule as planned in the PP or implementation plan? Yes

b. Are there any short falls or delays of project inputs? No

c. Are project assumptions holding up? Yes

d. Are progress/annual reports being submitted in a timely fashion? Delayed- Are such reports informative? Yes (but is now postponed.

e. Is there any monitoring/progress information being received from other than project or contractor personnel (e.g., project manager site visits, USAID reports etc.? Yes, but project manager site visits restricted due to travel limitations, also reports from other visitors to project.

f. Has an evaluation been carried out? Yes - Pes 3/79

g. Are there any audit or evaluation recommendations outstanding? No

h. Are there any special or restrictive requirements imposed by RAC or stipulated in the PP? No

Attachment: ABS Project Data Sheet

PROGRAM: CENTRALLY FUNDED

Project Manager: L.R. Frederick

Attachment A

TITLE N-Fixation Symbiotic	FUNDS Agriculture Rural Dev. & Nutrition	Proposed Obligation FY 1981 $500	Proposed Life of Project Cost $4752	Init. Oblig. FY 1975	Proposed Est. Final Oblig. FY 1983	Proposed Completion Date FY 1984
NUMBER 931-0613 Grant [X] Loan [ ] / New [ ] Continuing [X]	PRIOR REFERENCE -	FY 81 Oblig. Auth. by PP $0	Life of Project per App. PP $2952		Final Obligation per PP FY 1980	Completion Date per PP FY 1981
		Date of Last Intensive Evaluation: 2/77				

PURPOSE: Increase food production by use of tropical legumes. Build and test a collection of rhizobia effective on tropical legumes. Train junior scientists to work with rhizobia and biological nitrogen fixation (BNF). To learn how to utilize BNF in cropping systems. To build a network of scientists to test rhizobia locally, exchange cultures and information on how to help farmers.

BACKGROUND AND PROGRESS TO DATE: University of Hawaii has built a laboratory, greenhouse and field testing facility for study of rhizobia. Collection of rhizobia now numbers about 800 for tropical legumes. Agronomic work to devise ways to incorporate BNF and legumes into economic cropping systems has begun. Four training courses completed - 24 students, staff positions filled. Workshop to plan international trials held.

HOST COUNTRY AND OTHER DONOR: Cooperative field trials in countries still to be determined.

BENEFICIARIES: Directly - scientists working with BNF and tropical legumes. As knowledge and capability increases, to develop systems to benefit farmers who utilize BNF through legumes in their cropping systems. India and others which become part of international research network (not yet determined) at approx. $500.00/yr./country.

FY 1981 PROGRAM: Continue all activities outlined (above), especially international network of BNF researchers.

MAJOR OUTPUTS

	Thru FY1979	Life of Project
1. Culture collection	800	1000
2. Training LDC junior scientists	35	60
3. Selecting superior strains	-	-
4. Scientist network for field tests	N/A	20 countries
5. Inoculation methodology	-	-
6. Legume N - cropping system	-	-
7. Technical publications	3	-

I.D. FINANCED INPUTS:

	FY81 $000
Salaries	200
Training	30
Scientific Network	50
Travel	20
Operations	200
	$500

TECHNICAL OFFICE SUPPORT (in person months):

FY	DH	IPA	Consult.	RSSA	Total
1979	1.25	-	0.25	-	1.5
1980	1.5	-	1.0	-	2.5
1981	1.5	-	1.0	-	2.5

	Obligations ($000)	Expenditures ($000)	Unliquidated ($000)	Funding Period	Principal Contractors or Agencies & Contract Number
Through September 30, 1978	2189	1038	1151	XXXXXXXXXXXXXXXXXX	University of Hawaii (AID/ta-c-1207)
Estimated FY 1979	0	730	XXXXXXXXXXXXXXXXXXXX	Prior fund to 6/30/80	
Estimated Through FY 1979	2189	1768	421	XXXXXXXXXXXXXXXXXX	
Proposed FY 1980	800	730	XXXXXXXXXXXXXXXXXXXX	6/30/80 to 6/30/81	
Estimated Through FY 1980	2989	2498	491	XXXXXXXXXXXXXXXXXX	
Proposed FY 1981	500	Future Yr. Obligation 1263	Estimated Total Cost 4,752	6/30/81 to 6/30/81	

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CLASSIFICATION

PROJECT EVALUATION SUMMARY (PES) — PART I

Report Symbol U-447

PROJECT TITLE	2. PROJECT NUMBER	3. MISSION/AID/W OFFICE
-FIXATION-SYMBIOTIC, Tropical Legumes	932-0613.11	DS/AGR

4. EVALUATION NUMBER (Enter the number maintained by the reporting unit e.g., Country or AID/W Administrative Code, Fiscal Year, Serial No. beginning with No. 1 each FY)

☒ REGULAR EVALUATION ☐ SPECIAL EVALUATION

KEY PROJECT IMPLEMENTATION DATES			6. ESTIMATED PROJECT FUNDING	7. PERIOD COVERED BY EVALUATION
A. First PRO-AG or Equivalent FY 75	B. Final Obligation Expected FY 80	C. Final Input Delivery FY 81	A. Total $ 2,929,066 B. U.S. $ 2,929,066	From (month/yr.) 7/78 To (month/yr.) 1/79 Date of Evaluation Review Jan. 12-20, 1979

8. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

A. List decisions and/or unresolved issues; cite those items needing further study. (NOTE: Mission decisions which anticipate AID/W or regional office action should specify type of document, e.g., airgram, SPAR, PIO, which will present detailed request.)	B. NAME OF OFFICER RESPONSIBLE FOR ACTION	C. DATE ACTION TO BE COMPLETED
Continue project as planned, with minor adjustments as mutually agreed by Project Officer and Project Leader.	Frederick-DS/AGR Whitney U. Hawaii	6/81
Next evaluation by review team accompanied by Project Officer.	Frederick-DS/AGR	8/80

9. INVENTORY OF DOCUMENTS TO BE REVISED PER ABOVE DECISIONS

N/A

- ☐ Project Paper
- ☐ Financial Plan
- ☐ Logical Framework
- ☐ Project Agreement
- ☐ Implementation Plan e.g., CPI Network
- ☐ PIO/T
- ☐ PIO/C
- ☐ PIO/P
- ☐ Other (Specify) _____
- ☐ Other (Specify) _____

10. ALTERNATIVE DECISIONS ON FUTURE OF PROJECT

- A. ☒ Continue Project Without Change
- B. ☐ Change Project Design and/or ☐ Change Implementation Plan
- C. ☐ Discontinue Project

11. PROJECT OFFICER AND HOST COUNTRY OR OTHER RANKING PARTICIPANTS AS APPROPRIATE (Names and Titles)

Dr. Lloyd Frederick: DS/AGR/TSWM: [signature] Date 7 Mar 79

Mary Mozynski, DS/AGR: [signature] Date Mar. 8, 79

12. Mission/AID/W Office Director Approval

Signature [signature]

Typed Name Dr. Dean Peterson DS/AGR

Date

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PROJECT REVIEW SUMMARY

4/9 4/29 5/29

PROJECT TITLE: Nitrogen Fixation-Symbiotic Tropical Legumes

DATE OF REVIEW: 3/18/80

PROJECT NO.: 931-0613

DSB OFFICE/DIV.: Tropical Soil and Water Management

List actions to be taken (or issues to be resolved) as a result of Project Review Meeting	Action Officer	Date Action to be Completed
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Lloyd R. Frederick
Project Manager

Keith Byerge
Office Director

DS/PO OFFICIAL FILE

Clearance: DS/AGR, MMozynski

Attachments: AID Project Data Sheet
Project Review Information Sheet
Other:

Distribution: Project Files
DS/DAA
DS/PO: Program Analyst

70 4/1/80
4/9 5/29

Worksheet

AID 1350-1X (1-78)

PIO/T

DEPARTMENT OF STATE
AGENCY FOR
INTERNATIONAL DEVELOPMENT

PROJECT IMPLEMENTATION ORDER/TECHNICAL SERVICES

1. Cooperating Country: DS Bureau

Page 1 of 2 Pages

2. PIO/T No. 931-0613 – 3606490

3. ☒ Original ☐ Amendment No. 4/29/80

4. Project/Activity No. and Title (931-0613.11)
N.-Fixation Symbiotic - Hawaii

DISTRIBUTION

5. Appropriation Symbol: 72-1101021.3

6. Allotment Symbol and Charge: 043-36-099-00-20-01

7. Obligation Status: ☒ Administrative Reservation ☐ Implementing Document

8. Project Assistance Completion Date (Mo., Day, Yr.): 6/30/81

9. Authorized Agent: AID/W

10. This PIO/T is in full conformance with PRO/AG _____ Date NA

11a. Type of Action and Governing AID Handbook: ☒ AID Contract (HB 14) ☐ PASA/RSSA (HB 12) ☐ AID Grant (HB 13) ☐ Other

11b. Contract/Grant/PASA/RSSA Reference Number (If this is an Amendment): AID/ta-c-1207

12. Estimated Financing (A detailed budget in support of column (2) is attached as attachment no. 1)

		(1) Previous Total	(2) Increase	(3) Decrease	(4) Total to Date
Maximum AID Financing	A. Dollars	–	$742,548	–	$742,548
	B. U.S.-Owned Local Currency				

13. Mission References

14a. Instructions to Authorized Agent: This PIO/T provides final incremental funds totaling $742,548 for the third year of the three year extension of contract AID/ta-c-1207 with the University of Hawaii. The budget is included herein (see attachment 1). The scope of work, total estimated cost, estimated term and all other conditions of the contract remain the same.

Article # Voucher Identification. In each instance of voucher (SF1034) submission made by the contractor for payment hereunder the following identification data will appear on the face of the voucher:

Contract: AID/ta-c-1207
Project: 931-0613.11
Office: DS/AGR/TSWM-L.Frederick

FUNDS RESERVED BY
Williams
FOR
3/26/80

14b. Address of Voucher Paying Office
Office of Financial Management
Agency for International Development, Washington, D.C. 20523

15. Clearances—Include typed name, office symbol, telephone number and date for all clearances.

A. The project officer certifies that the specifications in the statement of work are technically adequate
DS/AGR/TSWM:LFrederick
DS/AGR:JMalcolm
Phone No. 235-8877
Date 3/18/80

B. The statement of work lies within the purview of the initiating and approved agency programs
DS/AGR:RSolem
Date

C. DS/AGR/TSWM:SEngberg
DS/AGR:MMozynski
Date 3/18/80
3/19/80

D. Funds for the services requested are available

E. DS/PO:MRechcigl
DS/PO:ASilver
Date 3/24/80
3/24/80

16. For the cooperating country: The terms and conditions set forth herein are hereby agreed to

Signature _____ Date _____

Title

17. For the Agency for International Development

Signature Kenneth A. Milow Date 3/25/80

Title Mr. Kenneth Milow, DS/PO

KPA 4-643
RAC Meeting
Oct. 17-18, 1974
9310613 (8) 18
PD-AAC-403 4p

Project Review

Agriculture

Nitrogen Fixation by Legumes as a Major Factor for Food Production in Less Developed Countries -- University of Hawaii.

Dr. M. L. Peterson, Chairman of the Subcommittee consisting of Drs. Heady and Whitney, summarized their report as follows:

(1) Does the proposal deal with an important current and future development problem in the LDC's? The Subcommittee is in full agreement that this is an important problem, especially so at this time of relative scarcity of energy and fertilizer. It is a problem of worldwide importance including the U.S., but more so in countries without natural gas resources and finances to purchase fertilizers manufactured elsewhere.

(2) Does the University of Hawaii provide the appropriate combination of resources to attack the problem? Hawaii has the interest, the senior professional staff, and the climate and soils for year around production of tropical legumes. However, the problem of adaptability of legume species and associated Rhizobia bacteria tends to be very specific and generalizations are risky. Further, full staffing at present is exceedingly thin for a project of the size, scope, and complexity outlined.

(3) Is the proposal sufficiently defined and the objectives addressed to the most critical issues? Although RIGC expressed concern over the possible competition with a newly proposed International Plant Nutrition Institute, since nutrition problems are site specific, there would appear to be no reason for conflict or duplication unless the new institute undertakes research that duplicates this project. Applied problems must be solved where they exist. This project is proposed as a three year project with possible extensions. This is not a short-term project; it probably would take 10 years of concentrated effort to see the project through to a successful conclusion. Hence, the 3 year initial funding is probably appropriate for an introductory phase. There is concern that the project is too broad and that the stated goals could not be achieved in the 3 years; objectives should be more narrowly defined. There are four approaches

to improve nitrogen fertility: (a) major food grain legumes, (b) crops grown for oil and protein, (c) legumes grown for improving the nutritional value of grazing land and harvested forages, and (d) crops to grow one's own nitrogen, requiring plentiful land. The project would be more manageable if major efforts were concentrated on the major grain legumes and oil crops.

Outreach and training programs: Bringing trainees to Hawaii appears adequate, but the field testing has not been well described. It is suggested that they seek collaborators at the outset who are willing and capable of growing selected legumes inoculated with available strains of Rhizobia to gain field data simultaneously with the work at Hawaii.

Budget Considerations: There is concern about the size of the budget and whether the amount requested could be efficiently absorbed considering the start-up time and the problem of enlisting cooperators. The two principle investigators devoting 25% of their time cannot manage a $900,000 program in three years.

Dr. Ready pointed out that under tropical conditions only a small percentage of the nitrogen fixed by legumes was available to the following crops which indicates that this is less a fixation problem and more a problem of the planned utilization by crop rotation and management.

Dr. Whitney indicated his agreement with the above report with an additional focus on the two problem areas which delimit the problem. (1) Identification and isolation of efficient Nitrogen fixing strains of Rhizobia with emphasis on innoculation methods, storage, and survival of the improved strains. This means concern for the relationship to the soils and environmental stress factors. It also poses the need for proof-testing, locally in a network of stations. (2) Development of cropping systems to exploit both tops and roots will take an extended period of time. There will be need for a soil chemist-physiologist to work out the distribution nitrogen capable of being reincorporated into the cropping system. This is a good problem capable of resolution. Dr. Milner having just joined the RAC Meeting commented on his review. This is a good project. It has strong ties to the basic sciences. He questioned whether the expertise at Hawaii is adequate. There are too many fringe objectives, and some need to be trimmed.

Dr. Schweigert asked about the site-specific parameter implications. Dr. Whitney indicated that each site for the proof-testing should

have a complete soil analysis in order to suggest the conditions under which transfer becomes possible. This is not explicitly detailed in the proposal. The project should also be coordinated with the other project on soils being conducted at the University of Hawaii.

Dr. Dean Peterson stated that he believed this to be one of the most important projects in the field of agriculture. We need to understand how bacteria fix nitrogen in order to determine how to improve the circumstances. This represents great opportunities for basic research. Dr. M. Peterson stated that there was related work going on at the University of Wisconsin a number of years ago, but it was dropped because of the cheap fertilizer. While there is some laboratory control testing planned in this project, there is a danger that too extensive a program of basic research would use up all the resources and delay the field work. They could go to the field directly with cooperation of institutions in the local field analyses.

Dr. Hagen raised questions about (1) utilization of the climatic variations in Hawaii as a part of the project, and (2) the meaning of the term"pelleting" in the proposal.

Dr. Leon Hesser, Acting Director of the Office of Agriculture, introduced Dr. Guy Baird, Associate Director, Dr. Donald Plucknett, Chief of the Soil and Water Management Division, and Dr. John L. Malcomb, Project Manager. John Malcomb stated that the project objectives should be trimmed and this will be done. Some looseness may be desirable in defining the area of variables to be studied. Guy Baird commented on the Consultative Group which is made up of 30 members which collectively fund 8 International Agricultural Research Centers. They have systematically considered how to fit the food legumes into the Centers' programs. However, limitations of funds limit the specialized staffing capabilities, and recognition is given to the integrated roles of other institutions in the total research programs. Consideration is being given to the establishment of another international center, namely, the International Plant Nutrient Institute (IPNI) at the initiation of the U.S. However there is no assurance that this will come about. The area is recognized as important, and undoubtedly, something will emerge. AID regards this project as an activity which will strengthen the network of activities in this field. The area merits considerably enhanced effort.

Motion: RAC approve the project with the recommendation that the AID staff negotiate further relative to the following matters: (1) greater input of the time of the principal staff, (2) greater participation of scientists from developing countries including financing, (3) narrowing initial objectives to those which can be achieved during the initial 3-year life of the project, namely, food legumes and oil crops, (4) greater attention to the interaction of this project to cropping systems in developing countries, (5) budget reduction for the initial 3-year program, and (6) that the Subcommittee be advised of the plan of action with reference to the sequence of research activities and an explanation of how this would be expanded to the field activities.

Moved by Dr. M. Peterson, seconded by Dr. Heady.

Vote: Unanimous approval

John E. Murphy, AID Deputy Administrator, having joined the group during the discussion of the nitrogen fixation project, was introduced to the RAC. He commented that he was most interested in an effective research program. It is clear that the total resources of the Agency are not sufficient to accomplish all of the goals without some possible breakthroughs in the research field. He expressed pleasure with the business-like approach of the RAC in narrowing down the objectives and the budget considerations of feasibility. Earlier reference had been made to an 18 month project review. Mr. Murphy indicated that he hoped there would be more close monitoring throughout the period of active project life. He was reassured by Dr. Hesser that project management involves continuous reviews on a monthly basis in addition to the special reviews which had been referred to. Mr. Murphy stated that he found this to be satisfying and hoped to visit the group again.

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS PART I

1. TRANSACTION CODE: A (A ADD, C CHANGE, D DELETE)

PAF

2. DOCUMENT CODE: 5

3. COUNTRY ENTITY: TA/AGR RDA-4
Type a. Research

4. DOCUMENT REVISION NUMBER: 931 0613 (7) PD-AAF-403 2/0

5. PROJECT NUMBER (7 digits): 931-0613

6. BUREAU/OFFICE: A. SYMBOL: TAB; B. CODE: 08

7. PROJECT TITLE (Maximum 40 characters): N-Fixation Symbiotic-Hawaii

8. PROJECT APPROVAL DECISION — ACTION TAKEN: A APPROVED, D DISAPPROVED, DE DEAUTHORIZED

9. EST. PERIOD OF IMPLEMENTATION (For Total Project): YRS 03 QTRS 0

10. APPROVED BUDGET AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. 1ST FY 75 F. GRANT	E. 1ST FY 75 G. LOAN	H. 2ND FY 76 I. GRANT	H. 2ND FY 76 J. LOAN	K. 3RD FY TQ L. GRANT	K. 3RD FY TQ M. LOAN
(1) FN	141 I	953	---	491	---	---	---	392	---
(2)									
(3)									
(4)									
			TOTALS	491	---	---	---	392	---

A. APPROPRIATION	N. 4TH FY 77 O. GRANT	N. 4TH FY 77 P. LOAN	Q. 5TH FY 78 R. GRANT	Q. 5TH FY 78 S. LOAN	LIFE OF PROJECT T. GRANT	LIFE OF PROJECT U. LOAN
(1)	76	---	---	---	959	---
(2)						
(3)						
(4)						
TOTALS	76	---	---	---	959	---

11. PROJECT FUNDING AUTHORIZED (ENTER APPROPRIATE CODE(S)) 1 - LIFE OF PROJECT, 2 - INCREMENTAL LIFE OF PROJECT: A. GRANT 2, B. LOAN -

C. PROJECT FUNDING AUTHORIZED THRU FY 77

12. INITIAL PROJECT FUNDING ALLOTMENT REQUESTED ($000)

B. ALLOTMENT REQUEST NO. _____

A. APPROPRIATION	C. GRANT	D. LOAN
(1)		
(2)		
(3)		
(4)		
TOTALS		

13. FUNDS RESERVED FOR ALLOTMENT

TYPED NAME (Chief, SER FM/FSD)

SIGNATURE

DATE

14. SOURCE/ORIGIN OF GOODS AND SERVICES: ☐ 000 ☐ 941 ☐ LOCAL ☐ OTHER _____

15. FOR AMENDMENTS, NATURE OF CHANGE PROPOSED

This amendment increases the approved budget of the subject project from $900,000 to $959,000 which has been necessitated by a rate of inflation higher than anticipated at the time the original budget was established in 1974. The contract for the subject project hereby will be increased from $882,799 to $958,999. All other conditions remain the same.

FOR PPC/PIAS USE ONLY	16. AUTHORIZING OFFICE SYMBOL	17. ACTION DATE (MM DD YY)	18. ACTION REFERENCE (Optional)	ACTION REFERENCE DATE (MM DD YY)

AID 1330-6 (7-76)

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS

PART II

ENTITY: TA/Bureau

PROJECT: N-Fixation Symbiotic - Hawaii

PROJECT NUMBER: 931-0613

I hereby authorize grant funds not to exceed $76,200 for a budget increase from $882,799 to $958,999 for the contract AID/ta-C-1207 on "N-Fixation Symbiotic" with the University of Hawaii. These additional funds are required due to increased project costs resulting from an inflation rate greater than anticipated at the time the original budget was established in 1974. The scope of work and all other conditions of the subject contract/project remain unchanged. This increase in funding will be made with either FY 77 or FY 78 funds depending on the availability of funds. The authorized budget for this project is hereby increased from $883,000 to $959,000.

M L Belcher for C Ferrar
Curtis Farrar
Assistant Administrator
for Technical Assistance

Date Aug 29 '77

Clearances:
TA/AGR/SWM:JMalcolm 7/28/77
TA/AGR/SWM:DPetersen DP
TA/AGR:GBaird 7/28/77
TA/AGR:LHesser 7/27/77
TA/RES:MRecheigl 7/27/77
TA/PPU:RSimpson

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS PART I

1. TRANSACTION CODE: C (A = ADD, C = CHANGE, D = DELETE)

PAF

2. DOCUMENT CODE: 5

COUNTRY/ENTITY: DS/AGR RDA-4

Type A Research

4. DOCUMENT REVISION NUMBER: 0

931-0613.11

PROJECT NUMBER (7 digits): 931-0613.11

6. BUREAU/OFFICE: A. SYMBOL: DSB; B. CODE: 36

7. PROJECT TITLE (Maximum 40 characters): N-Fixation Symbiotic-Hawaii

PROJECT APPROVAL DECISION — ACTION TAKEN: A APPROVED; D DISAPPROVED; DE DEAUTHORIZED

9. EST. PERIOD OF IMPLEMENTATION (Extension): YRS. 03 QTRS 0

10. APPROVED BUDGET AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C GRANT	PRIMARY TECH. CODE D LOAN	E. thru 9/30/77 F GRANT	E. thru 9/30/77 G LOAN	H. 1st FY 78 I GRANT	H. 1st FY 78 J. LOAN	K. 2nd FY 79 L GRANT	K. 2nd FY 79 M. LOAN
FN	141 I	953	--	959	--	498	--	738	--
			TOTALS	959	--	498	--	738	--

A. APPROPRIATION	N. 3rd FY 80 O. GRANT	N. 3rd FY 80 P. LOAN	Q. 4th FY 81 R. GRANT	Q. 4th FY 81 S. LOAN	LIFE OF PROJECT T GRANT	LIFE OF PROJECT U. LOAN
FN	757	--	0	--	2952	--
TOTALS	757	--	0	--	2952	--

11. PROJECT FUNDING AUTHORIZED (ENTER APPROPRIATE CODE(S)) 1 = LIFE OF PROJECT; 2 = INCREMENTAL, LIFE OF PROJECT: A. GRANT 2; B. LOAN

C. PROJECT FUNDING AUTHORIZED THRU FY 80

12. INITIAL PROJECT FUNDING ALLOTMENT REQUESTED ($000)

A. APPROPRIATION	B. ALLOTMENT REQUEST NO. C. GRANT	D. LOAN
TOTALS		

13. FUNDS RESERVED FOR ALLOTMENT

TYPED NAME (Chief, SER/FM/FSD)

SIGNATURE

DATE

14. SOURCE/ORIGIN OF GOODS AND SERVICES: ☐ OCD ☐ 941 ☐ LOCAL ☐ OTHER _____

15. FOR AMENDMENTS, NATURE OF CHANGE PROPOSED

This amendment provides for a three-year extension requiring additional funds totaling $1,993,000 for the subject project.

FOR PPC/PIAS USE ONLY	16. AUTHORIZING OFFICE SYMBOL	17. ACTION DATE MM DD YY	18. ACTION REFERENCE (Optional)	ACTION REFERENCE DATE MM DD YY

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS

PART II

ENTITY: DS/Bureau

PROJECT: N-Fixation Symbiotic - Hawaii

PROJECT NUMBER: 931-0613.11

1. I hereby authorize grant funds not to exceed $1,993,000 for a three-year extension of the research project on "Nitrogen Fixation-Symbiotic" with the University of Hawaii. The objective of this research is to maximize the fixation of nitrogen by grain and forage legumes in the tropical LDCs and thereby reduce the dependence of LDC farmers on more costly petroleum produced nitrogen fertilizer.

2. This project will be incrementally funded with $498,000 in FY 78; $738,000 in FY 79; and $757,000 in FY 80 for the first, second, and third contract years respectively, depending on the availability of funds.

3. This project was reviewed and endorsed by R & DC during its meeting on January 17, 1978 and by RAC at its meeting on March 30, 1978.

4. The contract for this three-year extension will be negotiated non-competitively with Hawaii based on predominant capability (Justification Memo enclosed herein).

Sander Levin
Assistant Administrator for
Development Support

Date: 5-9-78

References:

1. Research Project Statement: "Maximizing Symbiotic Fixation of Nitrogen by Grain and Forage Legumes in the Tropics" (attached)
2. Minutes of RAC Meeting - March 30, 1978
3. Minutes of R & DC Meeting - January 17, 1978

Clearances:

DS/AGR/SWM:LFrederick _____ Date 3 Apr 78
DS/AGR/SWM:DPeterson _____ Date 3 Apr 78
DS/AGR:FWilliams _____ Date 4/4/78
DS/AGR:MMozynski _____ Date 4/4/78
DS/AGR:LHesser _____ Date 4/4/78
DS/RES:MRechcigl _____ Date 4/12/78
DS/PO:RSimpson _____ Date 4/17/78

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

9310613 (11)
PN-AAC-403

TO : See Distribution

DATE: April 5, 1976

6p

FROM : TA/RES, Miloslav Rechcigl

SUBJECT: RAC Recommendations on Proposals Reviewed at March 22-23, 1976 Meeting

Attached for your information and appropriate follow-up is a summary of the recommendations of the Research Advisory Committee on project proposals reviewed at the March meeting.

Distribution:

AA/TA, C. Farrar
K. Levick
M. Belcher
E. Long
S. Butterfield
T. Brown
M. Kilgour
T. Arndt

TA/PPU, C. Fritz
J. Gunning
C. Molfetto
R. Mills
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AFR/DP, F. Moore
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LA/DR, W. Feldman
NE/TECH, J. Dalton
GC, A. R. Richstein
SER/IT, J. Kovach
SER/ENGR, J. Rixse
SER/CM/COD, R.J. O'Brien
FFP/POD, P. Sheehan
PPC/DPRE, A. Handly
PHA/POP, D. Mutchler
O/LAB, S. Moody

5010-110

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AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT IDENTIFICATION DOCUMENT FACESHEET

TO BE COMPLETED BY ORIGINATING OFFICE

1. TRANSACTION CODE (X APPROPRIATE BOX)
[X] ORIGINAL [ ] CHANGE [ ] ADD [ ] DELETE

PID

DOCUMENT CODE 1

2. COUNTRY/REGIONAL ENTITY/GRANTEE
Interregional - Research - KPA 4

3. DOCUMENT REVISION NUMBER

4. PROJECT NUMBER
931- 17-130-613

5. BUREAU
A. SYMBOL: TAB
B. CODE: 6

6. PROPOSED NEXT DOCUMENT
A. [ ] PRP [X] PP B. DATE MO. 10 YR. 75

7A. PROJECT TITLE - SHORT (STAY WITHIN BRACKETS)
[N-Fixation: Problems/Limiting Factors]

8. ESTIMATED FY OF AUTHORIZATION/OBLIGATION
A. INITIAL FY 76 B. FINAL FY 78

7B. PROJECT TITLE - LONG (STAY WITHIN BRACKETS)
[Symbiotic Nitrogen Fixation: Studies of Factors Limiting N-Fixation for LDC Crop Production]
Contractor : to be selected
Project Manager: Dr. L. Frederick, TA/AGR/SWM

9. ESTIMATED COST (LIFE OF PROJECT)
($000 OR EQUIVALENT, $1 = _____)

PROGRAM FINANCING	AMOUNT
A. AID APPROPRIATED	1250
B. OTHER U.S.	--
C. HOST GOVERNMENT	--
D. OTHER DONOR(S)	--
TOTAL	1250

10. ESTIMATED COSTS/AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION (ALPHA CODE)	B. PRIMARY PURPOSE CODE	C. PRIMARY TECH. CODE	FIRST YEAR D. GRANT	FIRST YEAR E. LOAN	ALL YEARS F. GRANT	ALL YEARS G. LOAN
FN			300		1250	
FN		(FY77	500)			
TOTAL			300		1250	

11. OTHER U.S. ($000)

A. PROGRAM TYPE	B. FIRST YEAR	C. ALL YEARS
H.I.G.		
PL 480-Title II		
TOTAL		

12. PROJECT GOAL (STAY WITHIN BRACKETS)
[Develop ways to deliver Rhizobium strains, alive and viable, to LDC farmers without resorting to refrigeration or other sophisticated storage and maintenance means. Make Rhizobia inoculants available for experimental purposes.]

13. PROJECT PURPOSE(S) (STAY WITHIN BRACKETS)
[Support research by key research workers to find new and better ways to deliver Rhizobia inoculant preparations to LDCs.]

[Countries involved: Worldwide LDCs.]

14. PLANNING RESOURCE REQUIREMENTS (STAFF/FUNDS)

15. ORIGINATING OFFICE CLEARANCE
SIGNATURE: Leon F. Hesser
TITLE: Acting Director, TA/AGR
DATE SIGNED: MO. DAY YR.

16. DATE RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION
MO. DAY YR.

AID 1330-2 (5-75)

SUMMARY OF RAC RECOMMENDATIONS TO A.I.D.

PROPOSALS REVIEWED AT THE MARCH 22-23, 1976 MEETING

1. **Nitrogen Fixation by Associative Grass-Bacteria Systems (New) - University of Florida.** Duration of Project, 3 years; estimated cost $890,000. Whitney, Adams, M. Peterson, Schweigert.*

   Recommendation: That (a) the research be delimited to the most critical and definitive experiments needed to determine the potential of domesticating grass-bacteria systems as determined by the project manager and contractor; (b) the delimited project be approved for a duration and funding period of two years at approximately $100,000 each year; (c) the proposed workshop focus on methods and experimental designs prior to initiation of the research to get the best thinking on ways and means to accomplish the goals.

   Note: It was clear that although they passed it, the RAC members as a whole were very uneasy about the motion as presented by the subcommittee, as it did not square well with the general discussion. As was found later, the real concerns of the subcommittee members were not surfaced in the discussion, and related primarily to their reluctance to rely so heavily on the professional resources of a single institution (while recognizing that Florida is the proper U.S. geographic location for centering this kind of research). Rather than recommending the more usual remedy for this type problem by broadening the professional base --as in 5, below--the subcommittee motion narrowed the project in a manner which clearly misfits the circumstances. Therefore, we plan to implement the project as approved, placing emphasis however upon organizing immediately the proposed workshop as a means of identifying most effective participating roles for scientists from other institutions, and establishing technical research priorities and refinement of design. From this, we anticipate a proposed project revision will be developed and brought to RAC, probably at a December meeting.

2. Fortification of Sugar and Iron: Field Study Prior to Implementation at a National Level (New) - Pan American Health Organization. Duration of project, 3 years; estimated cost, $621,799. Schweigert, Carter, Linder, Ludington.

   Recommendation: That the project be approved as requested subject to incorporation by AID staff into a revised project proposal the suggestions made by RAC and the peer reviewers. This revised proposal is to be reviewed by members of the RAC subcommittee. If the revised proposal is acceptable to the RAC subcommittee it may be immediately implemented; if major objection are made by the RAC subcommittee, the project will not be implemented until further review by the RAC, preferably at the May, 1976 meeting.

---

*RAC review subcommittee; chairman underscored

3. Crop Production and Land Potential of Benchmark Soils of Latin America (Augmentation) - University of Puerto Rico. Duration of project, 3 years; initiated January 1, 1975 at estimated cost $1,029,307. Estimated additional cost, $180,000.

Crop Production and Land Capabilities of a Network of Tropical Soil Families (Augmentation) - University of Hawaii. Duration of project, 3 years; initiated July 1, 1974 at estimated cost $1,182,252. Estimated additional cost $180,000. Whitney, Heady, D. Peterson, M. Peterson.

Recommendation: That (a) the report be accepted since it meets the intent of the original motion; (b) the increased funding be approved as requested for both the University of Hawaii and the University of Puerto Rico.

4. Poor Rural Households, Technical Change, and Income Distribution in LDCs (New) - Cornell, Purdue and Michigan State Universities. Duration of project, 3 years; estimated cost, $763,802. Heady, Montgomery, D. Peterson, Tanter.

Recommendation: That Phase I of the project be funded for one year to complete the first or coordination phase during which (a) data adequacy and quality will be examined; (b) data retrieval and evaluation for research design will be implemented; (c) methodology will be outlined in great detail; (d) the joint work plan will be developed; and (e) the Agricultural Development Council will write up a proposal which is consistent with the other proposals and the common framework. The joint work plan, suggested methodology, data evaluation and work calendar serving as the framework and basis for the implementation and conclusion phases then should be brought before RAC in October 1976. If RAC's evaluation at that time is negative, the project should be discontinued by the end of the fiscal year. If the work plan, methodology and network possibilities developed are promising and RAC's evaluation is positive, the project should be amended to continue for the two remaining years.

5. Development and Testing Methodologies and Instruments for Evaluating Community Education Programs (New) - Tuskegee Institute. Duration of project, 3 years; estimated cost, $446,677. Montgomery, Wittnebert, Anderson, Tanter.

Recommendation: That the proposal be funded as requested and a review after one year be held to assure that the following issues have been resolved; (a) a group of outstanding external consultants skilled in policy analysis and project evaluation be formed and used; (b) specific

functions in sectors of community action be identified for analysis; (c) procedures be established and appropriate steps taken involving collaborative participants from other countries; (d) preferred methods of data gathering and evaluative approaches be stated; (e) plans for participant training at Tuskegee Institute be worked out.

6. Research to Reduce or Eliminate Mutagenic Effects from a Promising New Antischistosomal Drug (New) - Johns Hopkins University. Duration of project, 2 years; estimated cost, $254,333. Carter, Adams, Merrill, Schweigert.

   Recommendation: That the project be approved at $254,333 for 2 years. The suggested component of research with non-human primates is desirable and may be considered as a separate proposal.

7. Sporozoite-Induced Immunity in Simian Malaria (Expansion) - New York University. Estimated additional cost, $259,836. Wishik, Carter, Merrill, Schweigert.

   Recommendation: That the proposal be approved as requested to include both sporozoite work and adjuvant research with a shift in emphasis to the former.

   Note: The project was initially approved by RAC in December, 1974 under the title, "Potentiation of the Effects of Anti-malarial Vaccine by Use of Immunological Adjuvants", for a 3-year period as part of the coordinated malaria immunity research program.

8. In-Vitro Production of Plasmodium falciparum Antigens (Expansion) - University of Hawaii. Duration of project, 2 years; initiated July 1, 1975 at estimated cost $100,435. Estimated additional cost, $39,000. Wishik, Carter, Merrill, Schweigert.

   Recommendation: That the project be expanded to include a biochemical component as requested.

9. Surgical and Engineering Research on Means of Fertility Control (Extension) - Battelle Memorial Institute. Duration of extension, 2 years, 3 months; estimated additional cost, $640,000. Connell, D. Peterson, Wishik, Wittnebert.

   Recommendation: That the requested extension be approved at a lower level of funding. RAC further recommends careful review and continued monitoring of each subproject and the deletion of certain of the tasks if they do not appear to be leading to equipment of major clinical importance.

   Note: The suggested lower level of funding was not specified, as it was recognized that this would be determined by the activities recommended in the motion.

10. Enhancement of Lactational Infertility and Infant Nutrition (New) - The Johns Hopkins University. Duration of project, 2 years; estimated cost $410,883. Wishik, Carter, Connell, Linder.

Recommendation: That the project be resubmitted to RAC at its next meeting to cover only clinical trials on a small number of women in Baltimore; and that the revised project statement include some demographic analysis and actuarial estimates concerning the potential impact of the method, if successful.

11. Simplified Techniques of Fertility Control (Extension) - The Johns Hopkins University. Duration of extension, 3 years; estimated additional cost $1,175,999. Connell, Merrill, Schweigert, Wishik.

Recommendation: That the requested extension of the project be approved as presented.

Note: The RAC review and approval of this project, "Simplified Techniques Fertility Control", was undertaken with RAC's full understanding that no implementation of the project activities would occur until and unless outstanding issues between the GC and PHA/POP have been resolved concerning the alleged conflict of project activities with the Agency Policy on Abortion.

12. Alternative Local Organization Strategies for Involving the Rural Poor in Development and Approaches to AID Implementation of these Strategies (New) - Development Alternatives, Inc. Duration of project, 30 months; estimated cost, $363,000. Tanter, Anderson, Montgomery, Heady.

Recommendation: That approval be given to (a) phases I and II (field work); (b) planning for phase III (guidance); and (c) budget between $227,000 and $375,000; with the conditions that the project: (1) include theoretical ideas to guide model specification so that causal directions can be inferred; (2) control extraneous variance of excluded variables; (3) avoid overlapping definitions among indicators; (4) reformulate "hypotheses" as "if.., then..." statements; (5) increase staff time per case and decrease numbers of cases; and (6) explore feasibility of applying decision analysis to prescription of guidelines.

93106 13 (12)
PD-AAF-403

August 1, 1977

2p

ACTION MEMORANDUM FOR THE ASSISTANT ADMINISTRATOR FOR TECHNICAL ASSISTANCE

FROM: TA/AGR, Leon F. Hesser

Problem: A higher rate of inflation than originally anticipated has caused the need for additional funds totaling $76,200 to adequately fund the research project "N-Fixation Symbiotic" with the University of Hawaii.

Discussion: The subject project was submitted to the RAC at an estimated cost of $900,000 and received its endorsement at the October 17-18, 1974 RAC meeting. RAC at that time recommended that the AID staff negotiate a budget reduction for the project's initial three years. A three year contract for the project was finally negotiated at a total cost of $882,799 which became effective on June 1, 1975. Although cost increases were taken into consideration during the negotiating process, the rate of inflation, estimated in 1974, has now proven to be too low. This has resulted in the need for supplemental funding of $76,200 in order to permit the project to operate at the programmed level.

Although the original budget figures for seven of the ten line items are now considered to be too low, (see attached memo: Whitney to Malcolm dated June 21, 1977 for detailed discussion of each item) the major project funding shortages are for "Equipment and Supplies" ($39,865) and for "Salaries and Wages" ($20,622). Hawaii had anticipated modest increases in costs of supplies and equipment, but not the extreme rise for some items such as electricity which more than doubled. The overall average cost of supplies has increased 35% above 1974 levels. Original cost estimates in 1974 anticipated a 4% annual increase in salaries but have averaged 5-7% per year since then. Although some savings have been made by delays in hiring personnel, major cut backs in student help will have to be made if additional fund are not forthcoming. This will greatly reduce project efficiency since the research and training staff would then have to devote some of their time to routine operations generally performed by the students. Other line items with significant shortages are "Subcontracts" ($6,684), "Travel" ($4,650) and "Participant Cost" ($4,317). In spite of Hawaii's efforts to keep costs down by such actions as deferred hiring, delaying the acquisition of one vehicle and a reduction in planned financial support for participants/trainees, funds remaining in the contract will not be sufficient to

continue operations at an optimum level up to the current contract termination date of May 31, 1978.

This project is scheduled to be extended for another three years at a total estimated cost of $2,000,000. This will require FY 78 funds of $500,000 for the first extension year. TA/AGR will conduct a project evaluation this October and prepare a revised PP in December or January.

Recommendation: That you sign the attached PAF which will increase the approved funding level of "N-Fixation Symbiotic" with the University of Hawaii from $900,000 to $959,000 and thereby require additional FY 77 (or FY 78) funds totaling $76,200.

Clearances:
TA/AGR/SWM:JMalcolm 7/28/77
TA/AGR/SWM:DPeterson
TA/AGR:GBaird
TA/RES:MRechcigl
TA/PPU:RSimpson

PD-AAF-403

April 4, 1978

3p

ACTION MEMORANDUM FOR THE ASSISTANT ADMINISTRATOR FOR DEVELOPMENT SUPPORT

THRU: DS/PO, Robert Simpson

FROM: DS/AGR, Leon F. Hesser

Problem: Your approval is required for a three-year extension costing $1,993,000 for the research project on "N-Fixation Symbiotic" with the University of Hawaii.

Background: This project extension will continue the productive research on symbiotic nitrogen fixation conducted by Hawaii during the past three years. Research on biological nitrogen fixation is a relatively new area of AID emphasis which began in 1975 as an outgrowth of the high cost of petroleum produced nitrogen fertilizers generated by the world-wide oil crises of the mid-seventies. This project extension will enable the contractor to conduct further basic research on the subject, to continue training of LDC scientists, to enlarge Hawaii's collection of superior Rhizobia strains which will be disseminated worldwide for further research, and to develop a formal network of LDC scientists for cooperative efforts to test Rhizobium strains and inoculation methodology under local LDC conditions.

Recommendation: That you approve the subject project extension by signing the PAF and Environmental Threshold Determination enclosed herein.

Attachments:

1. Project Authorization and Request for Allotment of Funds
2. Environmental Threshold Determination

Clearance:

DS/AGR/SWM:LFrederick Date 3 Apr 78
DS/AGR/SWM:DPeterson Date 4/3/78
DS/AGR:FWilliams Date 4/4/78
DS/AGR:MMozynski Date 4/4/78
DS/RES:MRechcigl Date 4/12/78

DS/AGR/SWM:SEngberg:3Apr78

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : TA/AGR, J. Malcolm

DATE: November 23, 1977

FROM : TA/RES, Miloslav Rechcigl

SUBJECT: Research Proposal Entitled "Maximizing Symbiotic Fixation of Nitrogen by Grain and Forage Legumes in the Tropics" - The University of Hawaii

We have reviewed the above research project proposal and have generated several issues that should be addressed in the preparation of the final project paper prior to its submission to R&DC or RAC. The major areas identified include:

1. The project paper describes a large research program rather than a specific research project or set of projects. Furthermore, the document appears to place undue emphasis on the development of an international service center rather than on research.

2. The paper does not clearly convey what has actually been accomplished to date and what remains to be done.

3. More detailed methodology should be provided for each of the proposed activities listed under "Research Purpose and Expected Products."

4. Clarification is required regarding the division of labor between the University of Hawaii and the University of California at Davis.

5. The paper does not provide sufficient rationale for the increased budget and seems to imply a long term commitment (10 years) by AID.

6. The paper does not clarify the relationship between this project and the proposed Title XII activity at the University of Hawaii.

7. Previous documents concerning this project do not utilize the term "NifTAL Project". This acronym should be defined to avoid confusion.

cc:
TA/AGR, L. Hesser
TA/PPU, R. Simpson
AA/TA, E. J. Long

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

O : TA/AGR, J. Malcolm

DATE: November 23, 1977

ROM : TA/RES, Miloslav Rechcigl

JBJECT: Research Proposal Entitled "Maximizing Symbiotic Fixation of Nitrogen by Grain and Forage Legumes in the Tropics" - The University of Hawaii

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6. The paper does not clarify the relationship between this project and the proposed Title XII activity at the University of Hawaii.

7. Previous documents concerning this project do not utilize the term "NifTAL Project". This acronym should be defined to avoid confusion.

cc: TA/AGR, L. Jessell

ATTACHMENT 9310613 (14) PD-AAF-403

January 20, 1972

6p

GUIDELINES FOR PREPARATION

OF THE

RESEARCH ANNUAL REPORT

The attached guidelines suggest the format and the detail for annual research reports that are required in all research contracts. The research contractor will submit thirty-five copies of the report with appendices to the A.I.D. Project Manager. The A.I.D. Project Manager will submit two copies to TA/RUR and two copies to the A.I.D. Reference Center.

The outline should prove useful to the contractor in preparing the report, and provide an improved basis for annual project reviews. The contractor is encouraged to develop a self-contained report as outlined below in approximately fifteen double-spaced pages. Additional material may be annexed as necessary for a comprehensive report. The fifteen page report is intended to provide a barebones statement of the effectiveness of research resources and methods in producing research results according to annual work plans, and the significance of these research results for the solution of the problem being addressed. Annexed material is essential for a critical review of assertions regarding findings, significance, etc.

REPORT SUMMARY 1/

A. 1. Project Title and Contract Number:

2. Principal Investigator, Contractor and Mailing Address:

3. Contract Period (as amended): 2/ from _____ to _____

4. Period covered by Report: from _____ to _____

5. Total A.I.D. funding of contract to date:

6. Total expenditures and obligations through previous contract year: 3/

7. Total expenditures and obligations for current year: 3/

8. Estimated expenditures for next contract year:

B. Narrative Summary of Accomplishments and Utilization

(In this space provide a concise statement of the principal accomplishments during (1) the period of the report and (2) life of the project in relation to research objectives and actual or potential operational significance.

This information does not substitute for a full discussion of the same points required in the body of the Annual Research Report as outlined below.)

1/ "Report Summary": Statistical Information (Item A) and the Narrative Summary of Accomplishments (Item B) should be reported on a single page. This page will be for general public use as well as project management purposes, and should be written for a general rather than a technical audience.

2/ Item 3 - Contract Period (as amended): Report the original date of the contract and closing date as prescribed by the contract or any amendment thereto.

3/ Items A 6-8: These items refer to expenditures including firm obligations by the contractor. Obligations are the contractor's legal but unpaid commitments, i.e., subcontracts, purchase orders, etc.; and other related accruals through the end of the reporting period. A "contract year" is one between anniversary dates of the contract.

ANNUAL RESEARCH REPORT

A. General Background

Prepare a concise statement that provides the background and rationale that led to the initiation of the project. This summary should state the nature and importance of the problem to which the research is addressed, and the rationale that links the research activity to the problem.

B. Statement of Project Objectives as Stated in the Contract

The purpose of this section is to record in a precise and concise way the objectives of the research project. The objectives as stated in the contract may have been interpreted, expanded or further defined in other documents and mutually agreed to by A.I.D. and the contractor. This section should reflect the contractual objectives as modified by these supplementary understandings.

C. Continued Relevance of Objectives

Does your research to date, or other circumstances, indicate a need for modification of project objectives as stated in the contract? If so, in what respects?

D. Accomplishments to Date

1. Findings: Provide a statement of the principal and significant findings and other accomplishments for the reporting period as they relate to the anticipated results in the year's work plan. (See material for the year similar to that requested in G.1. below for the coming year.)

Discuss the operational significance of the findings of the current year's research for attainment of project objectives as stated in Section B above. The discussion should include reference to existing knowledge, recent research findings by others, and cumulative findings and accomplishments of this project.

Also discuss side effects of the work, positive or negative. For example, do the findings to date suggest unexpected complications for the application of findings; do they suggest the need for more direct approaches to the problem than were originally anticipated; or is the research developing information and insights not expected in the scope of the work?

2. Interpretation of Data and Supporting Evidence:

Summarize briefly the evidence and analysis that support the findings cited above. To permit a critical analysis of the evidence and analysis, expand as necessary in an appendix to each copy of the report.

3. Research Design: State briefly any significant modifications made in the research design prior to the current reporting period.

Are the present techniques, instruments or mode of inquiry appropriate and/or optimal for the study design? In view of the findings of the past year or your experience with the research measures employed, do you recommend modifying (1) the research design or (2) research techniques? For example, have there been special problems of data availability, sampling, data processing, or ineffective techniques? Have research findings revealed technical relationships that suggest a continuation of present methods or do they suggest a new approach?

E. Dissemination and Utilization of Research Results

1. Briefly describe efforts made under the contract to disseminate the results of the research project. Attach as appendices two lists: (1) a bibliographic list and an abstract not exceeding 200 words of papers and publications developed under the contract and (2) a list of short statements that identify each known use of materials produced by the project for seminars, conferences, translations, or as background material for speeches, policy statements, etc.

2. Cite evidence and cases known to you that findings of the research project are being used in LDCs, the U.S., or both, in training, direct application to the problem, etc.

3. Has the experience of the past year suggested new or more effective ways to expand the use of research results? If so, discuss the experience and as appropriate include proposed steps in the work plan (Item G below). Indicate whether your proposals can be carried out under current provisions of the contract, or would require new contract arrangements by A.I.D.

4. Discuss the extent and nature of considerations to involve LDC personnel and/or institutions as an appropriate activity of the project. If judged appropriate, discuss the kind and extent of LDC involvement in (a) planning the project, (b) the execution of the field work, (c) the analysis and reporting of results. Plans to involve LDCs in the future should be reflected in the work plan in Item G (4) below.

5. Under separate cover forward four copies of publications, seminar reports, translations and other materials representing efforts to disseminate results of the research project, and evidence of the results being utilized by LDC or U.S. people or institutions.

F. Statement of Expenditures and Obligations and Contractor Resources

Provide a statement of expenditures and obligations related to the budget plan for the year. This statement should show expenditure and obligations for each of the (1) major inputs (Personnel, equipment, travel, etc.) according to (2) the major accomplishments or work targets that had been planned for the year's work.

Identify significant problems or accomplishments in the progress of the project related to the volume, effectiveness, or scheduling of the manpower, equipment, travel, etc., made available by these expenditures.

Discuss significant changes or modifications in project management, in the staffing pattern, physical facilities, institutional environment, etc.

G. Work Plan and Budget Forecast for Coming Year

Taking into consideration the past year's progress and expenditures and the work remaining to be done over the life of the project, present a work plan and budget for the coming year.

1. anticipated accomplishments for the coming year.

2. procedures to be used and activities to be carried out.

3. significant factors that you anticipate that will promote or impede accomplishments.

4. a plan for dissemination and utilization of the expected results of the research in the U.S. and in LDCs as applicable.

5. a budget statement that shows planned expenditures for each of the major inputs (personnel, equipment, travel, LDC involvement, etc.) according to the major accomplishments, or work targets that are planned for the coming year's work.

H. Appendices

Reports of technical data and analyses (Par. D. 2)
A bibliographic list with abstracts of papers and publications (Par. E. 1)
A list of uses made of research findings and reports (Par. E. 1)
Other appendices as appropriate.

Received Dec. 7, 1977
ERICKSEN
9318613 (15)
AAC-403

UNIVERSITY OF HAWAII

College of Tropical Agriculture
NifTAL Project

3p

November 9, 1977

Dr. John L. Malcolm
TA/OA/W
Agency for International Development
Department of State
Washington, D. C. 20523

VIA: Office of Research Administration

SUBJECT: NifTAL Extension Proposal (ta-C-1207)

Dear John:

Attached please find copies of our proposal for extending the NifTAL Project ("Maximizing Symbiotic Fixation of Nitrogen by Grain and Forage Legumes in the Tropics") for an additional three years. We will appreciate your assistance in arranging for the necessary reviews and documentation.

I would like to address four points which arose in the course of our telephone conversation last week.

1. USDA Rhizobium Repository: We are currently in the process of conducting two final testing series in the greenhouse and of preparing the necessary documentation preparatory to publishing a Rhizobium catalogue in cooperation with the World Data Center for Microorganisms, a U.N.-sponsored program at the University of Queensland, Australia. This catalogue will include all the strains which are considered to be worthy of distribution, based on tests conducted to date--probably about 100 strains. All of these strains will be simultaneously deposited with the USDA collection, either as lyophylized cultures or on dessicated beads. Additional cultures will then be automatically deposited with USDA as they are proven.

2. Plans for Testing in LDC's: We have deliberately established a conserative schedule for involving LDC cooperators because we believe it is essential to involve these cooperators in the planning process in order for the program to be successful. Thus, we plan to hold a planning workshop in the first year, followed by regional workshops as quickly as arrangements can reasonably be made. This aspect of the work will also

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require the employment of an additional microbiologist with considerable international experience, with its attendant lag period for recruitment and approval.

In the meantime, we are proceeding on two fronts: a) in cooperation with the Benchmark Soils Project, we are conducting strain tests in Hawaii and will subsequently conduct identical experiments in the Philippines to develop estimates of the transferability of symbiotic performance data within tropical soil families; and b) in cooperation with former trainees, we are carrying out tests on the persistence of Rhizobium (in peat carriers) shipped to various tropical countries in order to establish base-line information on the best ways of providing inoculum for LDC trials.

We are also developing linkages through our training programs, visits to LDC centers, and correspondence--all in preparation for the field-testing program.

3. Cost of Training Program: As discussed on page 28 of the proposal, the output line item for training includes not only the formal training courses, but also the staff time, supplies, etc. devoted to working with the four graduate research assistants plus individuals who come to NifTAL for intern-type training. We have had an excellent experience, for example, with an intern from Japan who was supported by the East-West Center Food Institute and contributed greatly to the NifTAL research program. We would like to involve LDC technologists in this way in the future. The major expense in this category is staff time. The average estimated cost of the training activities thus amounts to 10.5% of the total budget for the three year period.

4. Value of Superior Strains: The question here is whether or not significant responses can be obtained to inoculation of tropical legumes with introduced strains of Rhizobium. The literature supports the concept that plants which are relatively specific in their Rhizobium affiliation respond frequently to inoculation, and respond consistently when introduced into new areas. Legumes in this group which are grown in the tropics include soybean, chickpea, lentils, and faba bean. Other legumes which are intermediate in specificity respond less frequently. These would include common beans, Leucaena, African yam bean, and others. However, even in legumes (e.g. cowpeas and related crops)

which are quite promiscuous, there is scope for responses to inoculation when these crops are introduced into a new area--such as peanuts in Florida, U.S.A. In each situation where a nodulation response is possible, it is very advantageous to use the best strain which can be obtained, both in terms of the immediate production of the initial crop, and in terms of the persistence of this strain for subsequent crops. A less-than excellent strain which persists in the soil will make further improvement extremely difficult.

The NifTAL Project through the cooperative experiments on the Benchmark Project sites will soon have good information on the potential for increasing yield of soybeans and cowpeas through the use of strains which excelled in greenhouse tests. This work is scheduled to be expanded to additional sites. Additional information will also be forthcoming as LDC workers test NifTAL strains in the field prior to the formal network development.

I trust these comments will be helpful in clarifying our approach to maximizing symbiotic fixation of nitrogen by tropical agricultural legumes. Please let me know if there are any other questions which may need to be answered.

Sincerely yours,

Sheldon

A. Sheldon Whitney
Project Director/Principal Investigator

ASW:kyz

cc: B. B. Bohlool
W. G. Sanford

Endorsement

Philip Helfrich

Philip Helfrich, Associate Dean,
Research

9310612 (16)
N-AAF-463

UNIVERSITY OF HAWAII

College of Tropical Agriculture
NifTAL Project

June 21, 1977

5p

Mr. John L. Malcolm
Soil & Water Management Division
OA/TA/AID
Department of State
Washington, D. C. 20523

VIA: Office of Research Administration

Dear John:

I enclose the second revision for a supplementary budget to permit the project to operate at the programmed level through the contract period.

It would be most helpful to have as early an indication as possible as to when (and if) we may expect additional funds to become available.

Thanks very much for your assitance in this matter.

Sincerely yours,

A. Sheldon Whitney
Project Director

ASW:kyz

cc: W. G. Sanford
B. B. Bohlool
P. P. Rotar
Ruddy Wong

Endorsements:

P. P. Rotar, Chairman, Department of Agronomy & Soil Science

W. R. Furtick, Dean, College of Trop Ag.

Office of Research Administration

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96779

Supplementary Budget Request

Contract AID/ta-C-1207

Statistical

1.	**Title of Project:**	Maximizing Symbiotic Fixation of Nitrogen by Grain and Forage Legumes in the Tropics (NifTAL Project)
2.	**Principal Investigators:**	A. S. Whitney, W. G. Sanford, B. B. Bohlool
3.	**Contractor:**	University of Hawaii
4.	**Contractor's Address:**	c/o Office of Research Administration Honolulu, Hawaii 96822
5.	Address of Project Office:	P. O. Box 'O' Paia, Maui, Hawaii 96779
6.	Contract Period:	June 1, 1975 to May 31, 1978
7.	Contract Amount:	$882,799 for 3 years
8.	Additional Amount Requested:	$76,108 for the third year

Budget Calculations

Line Items	Expenses: Actual plus Estimated			Current Contract Funding	Requested Additional Funding
	1st 2 years	3rd year	Total		
Salaries & Wages	185,830	184,220	370,050	349,428	20,622
Fringe Benefits	31,590	31,317	62,907	62,898	9
Consultants	5,800*	5,000	10,800	11,040**	(240)
Overhead	55,190	55,634	110,824	103,853	6,971
Travel & Transportation	28,050	23,140	51,190	46,540	4,650
Publications	380	2,500	2,880	9,000	(6,120)
Equipment & Supplies	153,965	52,000	205,965	166,100	39,865
Vehicles (Lease)	6,968	4,132	11,100	11,750	(650)
Participant Costs	28,877	19,000	47,877	43,560	4,317
Subcontract	51,945	33,369	85,314	78,630	6,684
	548,595	410,312	958,907	882,799	76,108

*Excluding consultant travel
**Includes authorized transfer from salaries (3,000), fringe benefits (540) and overhead (1300).

	Professional	Non-professional*
Actual & Estimated: 1st 2 years	41	98
Estimated: 3rd year	42	90

*Excluding graduate research assistants and other student help.

Basis of indirect cost calculations:

	Approx. Man months Per Month	Percentage of Salary & Wages
A) Employees assigned at Manoa campus (student help and graduate assistants)	2	46.20
B) Employees assigned on Maui:		
a) Time assigned to research (including graduate assistants)	7	34.13
b) Time assigned to training (e.g. training courses, graduate students, etc.)	5	19.88

(Overall weighted average: 30.8%)

Narrative Justification

1. Salaries and Wages: When the budget was prepared in 1974, annual increases of 4% were used as the basis for estimated costs. However, in the three years since then, faculty salaries have increased by over 20% on the average (or 6-7% per year) instead of a planned 13%. Salaries of research associates increased by 45%. Savings have been made due to delays in hiring personnel, but this has only partially offset the large unexpected increases. The major cutbacks which will be required if additional funds are not forthcoming will be in the area of student help and other short-term or part-time assistants. This would greatly reduce the efficiency of the research and training staff since all routine but essential operations (cleaning etc.) would have to be done by them.

2. Fringe Benefits: Calculated as for salaries.

3. Consultants: We were able to obtain excellent consultants at rather minimum levels of compensation and thus did not exceed anticipated expenditures.

4. Overhead: Calculated as for salaries.

5. Travel and Transportation: Since 1974, international and local air fares have increased by about 30%. Also, the standard rate of per diem for overseas travel increased by 33%. This has been compensated for by a reduction in travel and by cost sharing (IITA, and EW Center). However, the project is now moving into a stage where greater coordination of testing efforts with researchers throughout the tropics is essential, and additional travel funds will be needed.

6. Publications: Although costs have increased significantly, funds from the workshop contract (ta-C-1267) were used to publish the workshop proceedings, reducing the level of expenditures in this category.

7. Equipment and Supplies: The contract proposal was prepared in April/May of 1974, before the very extreme increase in prices that occurred in late 1974 and 1975. We expected a modest increase in the cost of equipment, supplies and services, but not the extreme price increases actually encountered. As examples, the price of agar nearly doubled in one year and electrical rates have more than doubled since 1974. Many other items have also more than doubled in price. One the average the supplies we purchase cost approximately 35% more than the same supplies in 1974. As a result, we will not have sufficient funds to continue operations at an optimum level for the remaining life of the contract.

8. Vehicles (lease): Only modest increases in vehicle lease rates were encountered, and it was possible to offset this by delaying acquisition of one vehicle.

9. Participant Costs: The original plan was to offer scholarships, including round-trip air fare and stipend to all trainees who were selected for the course and who required such assistance. The drastic rise in air fares, however, required spending 67% of the allocation for 50% of the students.

On the advice of the review team, the policy was revised to offer a maximum of one-way air fare (return portion) plus stipend of $20 per day. This has meant that some of the most qualified applicants could not be considered due to unavailability of local funds. There has been no lack of qualified applicants, but additional funds are still necessary to provide for the one-way air transportation and to increase the very low stipend in keeping with the increased cost of living.

10. Subcontract: The subcontract leaders have experienced the same kinds of price increases as have occurred in Hawaii, and additional funding is likewise required to carry out the planned program.

COST REIMBUR .MENT CONTRACT WITH AN EDUCA..ONAL INSTITUTION

AGENCY FOR INTERNATIONAL DEVELOPMENT NEGOTIATED CONTRACT NO. AID/ta-C-1207

NEGOTIATED PURSUANT TO THE FOREIGN ASSISTANCE ACT OF 1961, AS AMENDED, AND EXECUTIVE ORDER 11223	TOTAL ESTIMATED CONTRACT COST See Article V
CONTRACT FOR: Legume Rhizobium Symbiosis Research PROJECT NO: 931-17-130-613-73	CONTRACTOR (Name and Address) University of Hawaii
ISSUING OFFICE (Name and Address) Agency for International Development Central Operations Division Office of Contract Maangement Washington, D. C. 20523	NAME c/o Contracts and Grants Office STREET ADDRESS 2450 Maile Way Honolulu, Hawaii CITY, STATE, AND ZIP CODE 96822
ADMINISTRATION BY Issuing Office	COGNIZANT SCIENTIFIC/TECHNICAL OFFICE TA/AGR
MAIL VOUCHERS (Original and 3 copies) TO: Agency for International Development Office of Financial Management Washington, D. C. 20523	ACCOUNTING AND APPROPRIATION DATA PIO/T NO. 931-17-130-613-73-3157573 APPROPRIATION NO. 72-11X1023 ALLOTMENT NO. 402-31-099-00-22-51
EFFECTIVE DATE June 1, 1975	ESTIMATED COMPLETION DATE May 31, 1978

The United States of America, hereinafter called the Government, represented by the Contracting Officer executing this Contract, and the Contractor, an educational institution chartered by the State of Hawaii with its principal office in Honolulu, agree that the Contractor shall perform all the services set forth in the attached Schedule, for the consideration stated therein. The rights and obligations of the parties to this contract shall be subject to and governed by the Schedule and the General Provisions. To the extent of any inconsistency between the Schedule and the General Provisions and any specifications or other provisions which are made a part of this contract, by reference or otherwise, the Schedule or the General Provisions shall control. To the extent of any inconsistency between the Schedule and the General Provisions, the Schedule shall control.

CERTIFIED A TRUE COPY THIS 28th DAY OF July 75
BY Robin Grindstaff

This Contract consists of this Cover Page, the Table of Contents, and the Schedule consisting of 7 pages, the General Provisions (Form AID 1420-23C), dated 9-74, and Additional General Provisions (Form AID 1420-23D), dated 9-74.

NAME OF CONTRACTOR UNIVERSITY OF HAWAII	UNITED STATES OF AMERICA AGENCY FOR INTERNATIONAL DEVELOPMENT
BY (Signature of authorized individual)	BY (Signature of Contracting Officer)
TYPED OR PRINTED NAME George K. Tanabe	TYPED OR PRINTED NAME V. C. Perelli
TITLE Comptroller - Contracts and Grants	CONTRACTING OFFICER
DATE JUN 25 1975	DATE JUN 26 1975

AID 1420-23A (4-73)

SCHEDULE
COST REIMBURSEMENT CONTRACT WITH
AN EDUCATIONAL INSTITUTION

Contract No. AID/ta-C-1207

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SCHEDULE

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GENERAL PROVISIONS

The General Provisions applicable to this contract consists of Form AID 1420-23C entitled "General Provisions - Cost Reimbursement Contract with an Educational Institution," dated 9-74, which includes provisions 1 through 38 ; and form AID 1420-23D entitled "Additional General Provisions - Cost Reimbursement Contract with an Educational Institution," dated 9-74, which includes provisions 1 through 18 .

SCHEDULE

ARTICLE I - STATEMENT OF WORK

For a period hereinafter set forth in the Schedule, the Contractor shall render technical advice and assistance to the Agency for International Development as more specifically provided for in Attachment A, Scope of Work, attached hereto and made part hereof.

ARTICLE II - KEY PERSONNEL

A. The key personnel which the Contractor shall furnish for the performance of this contract are as follows:

Key Personnel	Title
A. Sheldon Whitney	Program Co-Director
Burton L. Koch	Program Co-Director

B. The personnel specified above are considered to be essential to the work being performed hereunder. Prior to making any change in the key personnel, the Contractor shall notify the Contracting Officer reasonably in advance and shall submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on the program. The listing of key personnel may, with the consent of the contracting parties, be amended from time to time during the course of the contract to either add or delete personnel, as appropriate.

C. (1) The Contractor shall obtain A.I.D.'s approval to change the principal investigator or project leader, or to continue the research work during a continuous period in excess of three months without the participation of the approved principal investigator or project leader.

(2) The Contractor shall consult with A.I.D. if the principal

investigator plans to or becomes aware that he will, devote substantially less effort to the work than anticipated in the Scope of Work Plan. If A.I.D. determines that the reduction of effort would be so substantial as to impair the successful prosecution of the research, A.I.D. may request a change of principal investigator, terminate the research effort or make any other appropriate modification of the research agreement.

ARTICLE III - CHANGES IN RESEARCH METHODS, PROCEDURES, OBJECTIVES OR PHENOMENA UNDER STUDY

A. The principal investigator may change the methods and procedures employed in performing the research without making special reports on proposed actions or obtaining A.I.D. approval. However, significant changes in methods or procedures shall be reported to the Government in periodic or final technical reports. In the event the methodology or experiment is stated as a specific objective of the research work, any changes to either fall within the scope of paragraph B. below.

B. The stated objectives of the research effort shall not be changed, except with the prior written approval of the Contracting Officer.

C. The phenomenon or phenomena under study, i.e., the broad category of research, shall not be changed except with the prior written approval of the Contracting Officer.

ARTICLE IV - PERIOD OF CONTRACT SERVICES

The effective date of this Contract is June 1, 1975, and the estimated completion date of work, including final report(s), under this Contract is May 31, 1978.

ARTICLE V - ESTIMATED CONTRACT COST AND FINANCING

The Contractor will be reimbursed for the costs incurred in performing services hereunder in accordance with the applicable provisions of the Schedule and the General Provisions, subject to the following limitation made in respect thereto:

A. Total A.I.D. dollar funds available for payment and allotted to this Contract. See the clause of the General Provisions entitled "Limitation of Funds" and the article of the Schedule entitled "Budget".	$491,000
B. Estimated additional funds which may be provided, if funds are available. See the clause of the General Provisions entitled "Limitation of Funds" and the article of the Schedule entitled "Budget".	$391,799
Total Estimated Contract Cost	$882,799

NOTE: It is estimated that the aforesaid amounts will be sufficient to complete the work required hereunder as set forth in the Schedule article entitled "Statement of Work".

ARTICLE VI - BUDGET

BUDGET

LINE ITEM	FUNDS AVAILABLE FR: 06-01-75 TO: 12-31-76	ESTIMATED COST TO COMPLETION FR: 01-01-77 TO: 05-31-78	TOTAL
1. Salaries & Wages	$157,791	$ 194,637	$ 352,428
2. Fringe Benefits	28,493	34,945	63,438
3. Consultants	6,200	- 0 -	6,200
4. Overhead	43,696	61,457	105,153
5. Travel and Transportation	31,550	14,990	46,540
6. Publications	6,500	2,500	9,000
7. Equipment and Supplies	136,900	29,200	166,100
8. Vehicles (Lease)	6,900	4,850	11,750
9. Participant Costs	21,780	21,780	43,560
10. Subcontract	51,190	27,440	78,630
TOTALS	$491,000	$391,799	$ 882,799

The "Funds Available" figure represents the total funds authorized to be expended by the Contractor during the period indicated (see the Article of the Schedule entitled "Estimated Contract Cost and Financing" and the clause of the General Provisions entitled "Limitation of Funds"). Total contract expenditures shall not exceed the grand total of the funds available. Within the grand total, the Contractor may adjust Line Item amounts as reasonably necessary for the performance of the work.

The Contractor also agrees to furnish data which the Contracting Officer may request on costs expended or accrued under the Contract in support of the budget information provided herein.

ARTICLE VII - NEGOTIATED OVERHEAD RATES

A. Establishment of Postdetermined Indirect Cost Rates

Pursuant to the clause of the General Provisions of this Contract entitled "Negotiated Overhead Rates - Postdetermined", a rate or rates shall be established for each of the Contractor's accounting periods during the term of the Contract. Pending establishment of final indirect cost rates for the initial period, provisional payments on account of allowable indirect costs shall be made on the basis of the following provisional rates applied to the base(s) which are set forth below:

	Rate	Base	Period
On Campus	46.2%	Salaries and Wages	From: 1 Jun 1975 To : Until Amended
Off Campus	34.13%	Salaries and Wages	From: 1 Jun 1975 To : Until Amended

	Rate	Base	Period
Training (Off Campus)	19.88%	Salaries and Wages	From: 1 Jun 1975 To : Until Amended

Postdetermined indirect cost rates for subsequent periods shall be established in accordance with the terms of the "Negotiated Overhead Rates - Postdetermined" clause of this Contract.

ARTICLE VIII - ALTERATIONS IN CONTRACT

A. In accordance with Additional General Provision No. 3 entitled "Personnel", whereunder the Contractor may not send individuals outside of the United States to perform work under the Contract without the prior written approval of the Contracting Officer, the Contracting Officer does, hereby, provide said approval for those individuals required to travel outside the United States; provided, however, that concurrence with the assignment and/or travel of any and all said individuals outside the United States is obtained, in writing, from the Cognizant Technical Office of A.I.D. prior to their assignment and/or travel abroad.

This approval by the Contracting Officer shall not apply to any other clause or provision of this Contract which specifically requires Contracting Officer approval.

Prior to making any visits to less developed countries, the Contractor will review his plans with TA/AGR and will submit to TA/AGR 30 days prior to the intended trip a statement of purpose, length, and expected results, unless such 30 day advance notice is waived in

writing by TA/AGR. Contractor will, through TA/AGR, keep A.I.D. Missions in countries to be visited fully informed of proposed visits, ask them to provide any advice they wish regarding timing and content of the visits, and to participate to the extent that may be agreed on and will inform Missions of the trip outcomes. The Contractor will make necessary appointments and logistic arrangements.

B. Add General Provision No. 39 (Attachment B) entitled "Minority Business Enterprises Subcontracting Program";

C. Add General Provision No. 40 (Attachment C) entitled "Labor Surplus Area Subcontracting Program";

D. Add General Provision No. 41 (Attachment D) entitled "Small Business Subcontracting Program".

E. Consultants

Consultant services for a maximum number of 62 days will be reimbursed in connection with the services to be provided hereunder. No compensation for consultants will be reimbursed unless their use under the contract has the advance written approval of the Contracting Officer; and if such provision has been made or approval given, compensation shall not exceed, without specific approval of the rate by the Contracting Officer, (1) the current compensation or the highest rate of annual compensation received by the consultant during any full year of the immediately preceeding three years or (2) maximum daily salary rate of a Foreign Service Officer Class 1 whichever is less.

STATEMENT OF WORK

Conduct research in selected LDCs and at the University of Hawaii to determine more efficient legume-*Rhizobium* associations especially those suited to leached, acid tropical soils high in Al and low in bases.

A. Activities

1. Review and assess research completed and in progress relevant to successful systems for tropical legume-*Rhizobium* management,

2. Collect effective *Rhizobium* strains

a. Obtain better strains from existing collections

b. Isolate new strains from active nodules

c. Place particular emphasis on strains from target legumes

1) Primary species

a) *Arachia hypogaea*

b) *Cajanus cajan*

c) *Cicer arietinum*

d) *Dolichos lablab*, *D. biflorus*

e) *Glycine max*

f) *Lens esculens*

g) *Phaseolus vulgaris*, *P. mungo*, *P. aureus*, *P. radiato* *P. calcaratus* (some generic names now *Macroptilium*)

2) Secondary species

a) Tropical pasture legumes - *Centrosema*, *Desmodium*, *Glycine*, *Phaseolus* (*Macroptilium*), *Leucaena*, *Stylosanthes* spp.

b) Browse, covercrops and greenmanures - P. Canavalia, Crotolaria, Glyricidia, Seshania, Stizolobiu, etc.

c) Minor grain and vegetable legumes - P. lunatus, V. sesquipidalis, and Voandzeia subterrania.

3. Begin characterization and screening of Rhizobium strains.

4. Investigate specific nutrient requirements and tolerance of stress of promising Rhizobium strains.

5. Search for improved methods of legume seed innoculation to assure maximum effective modulation under target soil conditions.

6. Host a workshop for exchange of information on research in legume/Rhizobium systems and techniques for manipulation and experimentation with both host and bacterial strains.

B. Interim Goals

1. Form a network of collaborators in field.

a. Exchange bacterial strains and legume varieties

b. Exchange research information

c. Assist in exploration for and testing of Rhizobium strains and host legumes.

2. Identify five or more superior strains of Rhizobium for each legume in the Primary category listed above.

3. Identify one or more Rhizobium strains for 3 or 4

legumes which show exceptional tolerance to stress conditions High Al activity, low base status, high salt or high soil temperatures.

C. Services

1. Develop and distribute catalogue of superior Rhizobium strains identifying the most appropriate varieties of associated legumes. Describe the characteristics of each both advantages and limitations.

2. Develop training program and train 24 LDC specialists.

a. Prepare potential collaborators with necessary skills.

b. Train technicians to maintain cultures and distribute innoculum.

3. Distribute selected strains of Rhizobium strains for trial and demonstration.

4. Make limited distribution of Rhizobium strains for commercial multiplication and sale.

5. Assist establishing culture multiplication and distribution centers in developing countries.

D. Reports

Fifty (50) copies of the annual research reports shall be filed with AID/W 45 days after each anniversary date of the start of the project. Technical reports shall be prepared and issued by the contractor to reflect significant accomplishments or pivotal times. It is suggested that a distinctive format and cover be

selected for the technical reports so that they may be recognized as a series relating to one project. Preparation of annual report should follow guidelines dated January 20, 1972, a copy of which is attached to this contract.

General Provision No. 19

MINORITY BUSINESS ENTERPRISES SUBCONTRACTING PROGRAM (FPR 1-1.1310.2)

(a) The Contractor agrees to establish and conduct a program which will enable minority business enterprises (as defined in the clause entitled "Utilization of Minority Business Enterprises") to be considered fairly as subcontractors and suppliers under this contract. In this connection, the Contractor shall -

(1) Designate a liaison officer who will administer the Contractor's minority business enterprises program.

(2) Provide adequate and timely consideration of the potentialities of known minority business enterprises in all "make-or-buy" decisions.

(3) Assure that known minority business enterprises will have an equitable opportunity to compete for subcontracts, particularly by arranging solicitations, time for the preparation of bids, quantities, specifications, and delivery schedules so as to facilitate the participation of minority business enterprises.

(4) Maintain records showing (i) procedures which have been adopted to comply with the policies set forth in this clause, including the establishment of a source list of minority business enterprises, (ii) awards to minority business enterprises on the source list, and (iii) specific efforts to identify and award contracts to minority business enterprises.

(5) Include the Utilization of Minority Business Enterprises clause in subcontracts which offer substantial minority business enterprises subcontracting opportunities.

(6) Cooperate with the Contracting Officer in any studies and surveys of the Contractor's minority business enterprises procedures and practices that the Contracting Officer may from time to time conduct.

(7) Submit periodic reports of subcontracting to known minority business enterprises with respect to the records referred to in subparagraph (4), above, in such form and manner and at such time (not more often than quarterly) as the Contracting Officer may prescribe.

(b) The Contractor further agrees to insert, in any subcontract hereunder which may exceed $500,000, provisions which shall conform substantially to the language of this clause, including this paragraph (b), and to notify the Contracting Officer of the names of such subcontractors.

General Provision No. 40

LABOR SURPLUS AREA SUBCONTRACTING PROGRAM (FPR 1-1.805-3(b))

(a) The Contractor agrees to establish and conduct a program which will encourage labor surplus area concerns to compete for subcontracts within their capabilities. In this connection, the Contractor shall-

(1) Designate a liaison officer who will (i) maintain liaison with duly authorized representatives of the Government on labor surplus area matters, (ii) supervise compliance with the Utilization of Concerns in Labor Surplus Areas clause, and (iii) administer the Contractor's "Labor Surplus Area Subcontracting Program";

(2) Provide adequate and timely consideration of the potentialities of labor surplus area concerns in all "make-or-buy" decisions;

(3) Assure that labor surplus area concerns will have an equitable opportunity to compete for subcontracts, particularly by arranging solicitations, time for the preparation of bids, quantities, specifications, and delivery schedules so as to facilitate the participation of labor surplus area concerns;

(4) Maintain records showing procedures which have been adopted to comply with the policies set forth in this clause. Records maintained pursuant to this clause will be kept available for review by the Government until the expiration of 1 year after the award of this contract, or for such longer period as may be required by any other clause of this contract or by applicable law or regulations; and

(5) Include the Utilization of Concerns in Labor Surplus Areas clause in subcontracts which offer substantial labor surplus area subcontracting opportunities.

(b) A "labor surplus area concern" is a concern that (i) has been certified by the Secretary of Labor (hereafter referred to as a certified-eligible concern) regarding the employment of a proportionate number of disadvantaged individuals and has agreed to perform substantially in or near sections of concentrated unemployment or

underemployment, in persistent or substantial labor surplus areas, or in other areas of the United States or (2) is a noncertified concern which has agreed to perform a substantial proportion of a contract in persistent or substantial labor surplus areas. A certified-eligible concern shall be deemed to have performed a substantial proportion of a contract in or near sections of concentrated unemployment or underemployment, in persistent or substantial labor surplus areas, or in other areas if the costs that the concern will incur on account of manufacturing or production in or near such sections or in such areas (by itself, if a certified concern, or by certified concerns acting as first-tier subcontractors) amount to more than 25 percent of the contract price. A concern shall be deemed to have performed a substantial proportion of a contract in persistent or substantial labor surplus areas (by itself or its first-tier subcontractors) if the costs that the concern will incur on account of production or manufacturing in such areas amount to more than 50 percent of the contract price.

(c) The Contractor further agrees to insert, in any subcontract hereunder which may exceed $500,000 and which contains the Utilization of Concerns in Labor Surplus Areas clause, provisions which shall conform substantially to the language of this clause, including this paragraph (c), and to notify the Contracting Officer of the names of such subcontractors.

SMALL BUSINESS SUBCONTRACTING PROGRAM (FPR1-1.710-3(b))

(a) The Contractor agrees to establish and conduct a small business subcontracting program which will enable small business concerns to be considered fairly as subcontractors and suppliers under this contract. In this connection, the Contractor shall-

(1) Designate a liaison officer who will (i) maintain liaison with the Government on small business matters, (ii) supervise compliance with the Utilization of Small Business Concerns clause, and (iii) administer the Contractors "Small Business Subcontracting Program."

(2) Provide adequate and timely consideration of the potentialities of small business concerns in all "make-or-by" decisions.

(3) Assure that small business concerns will have an equitable opportunity to compete for subcontracts, particularly by arrandging solicitations, time for the preparation of bids, quantities, specifications, and delivery schedules so as to facilitate theparticipation of small business concerns. Where the Contractor's lists of potential small business subcontractors are execessively long, reasonable effort shall be made to give all such small business concerns an opportunity to compete over a period of time.

(4) Maintain records showing (i) whether each prospective subcontractor is a small business concern, (ii) procedures which have been adopted to comply with the policies set forth in this clause, and (iii) with respect to the letting of any subcontract (including purchase orders) exceeding $10,000, information substantially as follows:

(A) Whether the award went to larg or small business.

(B) Whether less than three or more than two small business firms were solicited.

(C) The reason for nonsolicitation os small business if such was the case.

(D) The reason for small business failure to receive the award if such was the case when small business was solicited.

The records maintained in accordance with (iii) above may be in such form as the Contractor may determine, and the information shall be summarized quarterly and submitted by the purchasing department of each individual plant or division to the Contractor's cognizant small business liaison officer. Such quarterly summaries will be considered to be management records only and need not be submitted routinely to the Government; however, records maintained pursuant to this clause will be kept available for review by the Government until the expiration of 1 year after the award of this contract,or for such longer period as may be required by other clause of this contract or by applicable law or regulation.

(5) Notify the Contracting Officer before soliciting bids or quotations on any subcontract (including pruchase orders) in excess of $10,000 if (i) no small business concern is to be solicited, and (ii) the Contracting Officer's consent to the subcontract (or ratification) is required by a "Subcontracts" clause in this contract. Such notice will state the Contractor's reasons for nonsolicitation of small business concerns, and will be given as early in the procurement cycle as possible so that the Contracting Officer may give SBA timely notice to permit SBA a reasonable period to suggest potentially qualified small business concerns through the Contracting Officer. In no case will the procurement action be held up when to do so would, in the Contractor's judgment, delay performance under the contract.

(6) Include the Utilization of Small Business Concerns clause in subcontracts which offer substantial small business subcontracting opportunities.

(7) Cooperate with the Contracting Officer in any studies and surveys of the Contractor's subcontracting procedures and practices that the Contracting Officer may from time to time conduce.

(8) Submit quarterly reports of subcontracting to small business concerns on either Optional Form 61, Small Business Subcontracting Program Quarterly Report of Participating Large Company on Subcontract Commitments to Small Business Concerns, or such other form as may be specified in the contract. Except as otherwise provided in this contract, the reporting requirements of this subparagraph (8) do not apply to small business contractors, small business subcontractors, educational and nonprofit institutions, and contractors or subcontractors for standard commercial items.

(b) A "small business concern" is a concern that meets the pertintent criteria established by the Small Business Administration and set forth in section 1-1.701 of the Federal Procurement Regulations.

(c) The Contractor agrees that, in the event he fails to comply with his contract obligations concerning the small business subcontracting program, this contract may be terminated, in whole or in part, for default.

(d) The Contractor further agrees to insert, in any subcontract hereunder which may exceed $500,000 and which contains the Utilization of Small Business Concerns clause, provisions which shall conform substantially to the language of this clause, including this paragraph (d), and to notify the Contracting Officer of the names of such subcontractors.