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**BIOLOGICAL NITROGEN FIXATION FOR FOOD PRODUCTION IN THE TROPICS**

**CONTRACT AID/DSAN-G-0101**

**ANNUAL REPORT**

**1982**

**SUBMITTED TO THE**

**U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT**

**by the**

**Department of Agronomy and Soils  
College of Agricultural Sciences  
University of Puerto Rico, Mayaguez Campus  
Mayaguez, Puerto Rico**

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**REPORT SUMMARY**

**STATISTICAL SUMMARY**

**TITLE:** Biological Nitrogen Fixation for Food Production in the Tropics (BNF Project)

**CONTRACT:** AID/DSAN-G-0101

**PRINCIPAL INVESTIGATOR:** Eduardo C. Schroder

**CONTRACTOR:** University of Puerto Rico  
Mayaguez Campus  
Mayaguez, Puerto Rico

**CONTRACT PERIOD:** January 1, 1979 - December 31, 1983

**REPORTING PERIOD:** January 1, 1982 - December 31, 1982

**TOTAL AID FUNDING:** \$360,000

## SUMMARY ACCOMPLISHMENTS

The year 1983 found the UPR-BNF Project involved in many activities which mark the accomplishment of several of the grant objectives. With regard to research aspects, they have involved inoculation response studies of important grain legumes such as pigeonpeas and beans as well as completion of field studies concerning inoculation response in a tropical forage-tree legume, Leucaena leucocephala.

Other areas of research with soybeans and native legumes were also started during 1982.

Training activities continued at the undergraduate level with the teaching of the Soil Microbiology course and at the graduate level with three local students working towards their M.S. degree.

A major activity accomplished in 1982 was the First International Workshop on Practical Applications of Azolla for rice production. The Workshop was held at Mayaguez during November 17-19; scientists from South America, Europe, Asia and the United States participated in the scientific and field sessions. Local interest was also demonstrated, and total attendance was over 50.

In order to ensure continuation of an active Soil Microbiology program at UPR, several proposals were sent to different grant agencies. Approval of submitted proposals are still pending.

A matter of concern is the slow development of International linkages; some progress has been made towards strengthening cooperative efforts with Guatemala and the Dominican Republic.

## GENERAL BACKGROUND

In January 1979, the U.S. Agency for International Development (AID),

approved a 3 year institution-strengthening grant to the University of Puerto Rico (UPR) to study Biological Nitrogen Fixation (BNF) for Food Production in the Tropics. This was preceded by the BNF component of Grant AID/csd-2857 - Classification and Microbiology of Tropical Soils which helped the University of Puerto Rico, Mayaguez Campus to develop facilities for a soil microbiology laboratory. The contract period was recently extended to December 31, 1983.

### INTRODUCTION

The grant objectives focus on the development and improvement of the University of Puerto Rico's institutional response capacity in the area of Biological Nitrogen Fixation (BNF).

The objectives of the grant can be considered under three types of outputs:

1. Research to exploit BNF for crop production
2. Training personnel from LDC's and
3. Advisory activities

### RESEARCH ACTIVITIES

#### 1. Leucaena inoculation trials

In coordination with NIFTAL (Hawaii), experiments following the basic design of the International Network of Legume Inoculation Trials (INLIT) were set up. The objective of this project was to determine whether there is a need to inoculate Leucaena leucocephala, under Puerto Rico tropical soil conditions. Leucaena leucocephala cultivar K-8 was established on July 30, 1980 at the Isabela Experimental Station on a pH 6.6 oxisol. The three basic treatments included were:

- a. Inoculated with Rhizobium (TAL 82, TAL 582 and TAL 1145);
- b. not inoculated
- c. not inoculated and fertilized with N (urea)

Two weeks after planting, estimates of emergence indicated that N-fertilized treatments had significantly lower germination (Table 1).

TABLE 1  
Visual estimates of emergence of *Leucaena leucocephala*

<u>Treatment</u>	<u>N</u>	<u>Rhizobium</u>	<u>Estimates *</u>
F1 (not inoculated)	-	-	3.25
F2 (urea)	+	-	1.75
F3 (inoculated)	-	+	2.25
M1	-	-	3
M2	+	-	1.75
M3	-	+	3.5

LSD = 1.79

\*0 = worst, to 4 = best

Nine weeks after planting, plants were sampled and nodules counted and identified serologically. The number of nodules found on the N-fertilized treatment were lower than at the other treatments. Non-inoculated controls did not differ from inoculated plants in the number of nodules indicating that adequate numbers of native Rhizobium specific for Leucaena were present in the soil. Serological analysis (Table 2) showed that 98% of the nodules reacted with the antiserum belonging to the inoculant strains, of which 72% of the nodules tested were formed by TAL 582 (CB 81).

TABLE 2

Distribution of the results of the serological identification of Leucaena leucocephala nodules

Treatments	ANTISERA				Total
	TAL 82	TAL 582	TAL 1145	Unknown	
	(number of nodules that reacted positively)				
F1	3	37	7	0	47
F2	1	0	1	0	2
F3	1	46	7	1	55
M1	0	26	8	0	34
M2	3	23	7	3	36
M3	0	22	17	0	39
TOTAL	8 (3.76%)	154 (72.3%)	47 (22.06%)	4 (1.88%)	213

Leucaena was harvested five times and dry matter yield/ha calculated. Inoculated treatments gave significantly higher yields, but P and K fertilization did not increase yields. N contents were not affected by experimental treatments. The high yields obtained (up to 16 tons dry matter/ha) indicate the need for continued research on Leucaena as a potential forage for cattle or biomass production in Puerto Rico.

## 2. Inoculation trials of pigeonpea

The objective of these experiments was to determine, under field conditions, whether the yield of pigeonpeas could be increased by inoculating with selected strains of Rhizobium. Two experiments were planted at Isabela and Fortuna sub stations. The basic treatment included:

- a. seeds inoculated with a specific strain of Rhizobium (8 treatments);
- b. non-inoculated seeds and
- c. non-inoculated seeds plus nitrogen (urea)

The 10 treatments were replicated four times. Since pigeonpea does not respond to fertilization in Puerto Rico, neither P or K were applied. Plots consisted of 4 rows arranged in a 2.4 m x 7.5 m area. Cultivar 2B-Bushy (determined) was sown.

The experiment at Fortuna Experimental Station gave very erratic results due to soil factors (herbicides or high N content) and damage by insects. Plants examined for nodulation lacked nodules and Rhizobium counts indicated that population was below the minimum to be detected.

Plants at Isabela Experimental Station were sampled 30 days after planting (DAP) and plant height was measured. Sampling for nodule count, weight and identification was done 45 DAP. At harvest, two control rows of each plot were harvested and green yield measured. Plant samples were harvested, dried, ground and analyzed for N content. There were small differences among treatments in plant height, nodule weight and nodule numbers. Strains 32Z3 and IHP 100 (India) gave significant higher yields but the N fertilization treatment had the maximum total N (Kjeldahl). No overall superior treatment was obvious. This can be explained with the results from serological analysis, since most nodules were formed by non-inoculant strains. Only strain IHP 155 (India) formed over 30% of the nodules when introduced in the inoculant. These results indicate the need to keep selecting Rhizobium strains able to fix N and compete with local strains, and to determine whether a larger number of bacteria at inoculation can increase pigeonpea yields.

### 3. Evaluation of inoculation methods for pigeonpeas (Cajanus cajan)

The objective of this experiment is to compare the nodulation and yield response of pigeonpeas (Cajanus cajan) to inoculation with

Rhizobium spp. utilizing different inoculation methods.

Preliminary experiments indicate that pigeonpeas does not respond to seed inoculation under Puerto Rican conditions. It is possible that unfavorable conditions prevent nodulation by the inoculant strain. Therefore, other inoculation methods should be tested, aimed at:

1. increasing the number of nodules formed by the strain used in the inoculant, and
2. testing the competitiveness of introduced strains with indigenous populations of Rhizobium

A field experiment was planted at the Fortuna substation (Mollisol) on September 25, 1981. Pigeonpea line 147 was sown. Plots consisted of 4 rows arranged in a 2.4 x 7.5 m area. Treatments were: 1) control not inoculated; 2) not inoculated with N fertilizer; 3) seed inoculation (arabic gum slurry); 4) seed inoculation (pelleting with rock phosphate); 5) granular inoculant (soil applied) and liquid soil inoculant. Plots were hand sown and precautions to avoid contamination were stressed.

Plants were sampled for nodulation and strain identification 35 DAP. Green pods were harvested on January 12, 1982, using the 2 center rows. Preliminary analysis indicated that there was no effect of treatments on yield. It is possible that the number of Rhizobium cells in the inoculants were very low or that the native population was able to compete with the introduced Rhizobium. Strain identification utilizing str resistance marker revealed an extremely low percentage of nodules (0.897%) belonging to the inoculant strain. The number of nodules/plant and further statistical analysis may reveal other factors affecting the results.

#### 4. Effect of mulching on Phaseolus vulgaris nitrogen fixation

The objective of this experiment was to evaluate the effects of different kinds of mulches on the symbiotic relationship of Rhizobium phaseoli and Phaseolus vulgaris.

A field experiment was established in Adjuntas substation (Limanf) in January, 1982. Treatments applied to each plot included: a) coffee pulp; b) coffee straw; c) leucaena leaves; d) black plastic; e) "aluminum" plastic, f) baggase; and g) control. Plots (2.4 m x 5.0 m) were arranged in a randomized complete block design with 4 replications. All seeds except control treatments were inoculated with a commercial culture of Rhizobium phaseoli.

During the growth period, samples were taken to evaluate root nodulation (number and weight) and dry weight of plant top. Soil temperature at 2 depths were followed by daily measurements through soil probs. At harvest time, yield of grain and dry weight of aerial parts were determined. Preliminary results indicate that treatments had no effect on nodulation. Yield data will be analyzed statistically.

#### 5. Nodulation survey of local legumes

A survey of the nodulation status of legume plants (herbaceous, shrubs and trees) was started. It is urgent that the nodulation status of rare and endangered species be studied before these important resource for the future are devastated by the rapid exploitation of tropical regions.

Delonix regia (flamboyant, royal poinciana) is a beautiful fast-growing tree, very abundant in Puerto Rico and the Caribbean area.

Several authors have not been able to find nodules, but very sparse white nodules were observed in Singapore by Lim and Ng. In order to confirm ~~the nodulation status of this tree~~, many field-grown seedlings have been observed, but all lacked nodules. Greenhouse experiments have been conducted with trees grown from seed inoculated with different strains of Rhizobium both in Leonard jars (sand) and pots (soil) without a trace of nodules. Recently, a culture of presumed Delonix Rhizobium was obtained from Dr. G. Lim; but when plated on YEM two different colony types were observed, and none resembled typical rhizobia colonies.

Further experiments with these isolates are under way, but all results indicate that Delonix; like several other Caesalpinioideae lack nodules. Therefore, none of these legumes can be recommended to build up soil nitrogen.)

The nodulation status of other Caesalpinioideae has also been observed; Cassia alata, Caesalpinia coriaria and Stahlia monosperma failed to nodulate. This is the first report on the non-nodulating character of this last species.

Survey of other legume species show that they were frequently nodulated. Among the Mimosoideae, we have found nodules on Mimosa ceratonia. Among the Papilionoideae, Sabinea spp. and Pictetia aculeata have been recorded as nodulated for the first time.

Rhizobium strains are being isolated from those species of legumes that have previously not been recorded as being nodulated. Those strains will be used for nodulation experiments and further characterization.

#### 6. Sequential cropping in soybeans

Several possibilities are available for soybean production in tropical areas concerning the number of crops grown per year, because of the availability of cultivars from different maturity groups. In order to evaluate these possibilities, Dr. S. Cianzio started field experiments at Isabela and Lajas Research Centers to compare different planting dates and protein yields of cultivars from different maturity groups. This provided the opportunity to observe the effect of inoculation on different dates and cultivars under tropical conditions. Bi-monthly experiments were planted with soil applied (granular) inoculant prepared with strain USDA I-110SN R. japonicum. Plants were sampled 4 to 6 weeks after planting, nodules counted and its contents planted on YEM with and without streptomycin to determine the percentage of nodule resulting from the inoculant strain.

Experiments are underway, but early results indicate that a large number of nodules were formed by the marked strain.

#### TRAINING ACTIVITIES

The P.I. of the Project is currently the chairman of the graduate committee of three graduate students (M.S. level) of the Department of Agronomy and Soils of UPR. One of them, Mr. Ismael Matos has completed his course work and research project (pigeonpea trials). At present, he is writing his thesis and expects to graduate in May 1983.

A second student, Ms. Raquel Robledo has completed her field experiments (mulching effects on P. vulgaris) and will complete her course program during the first semester of 1983.

The third student, Ms. Sarah Lugo has finished her course and will

start her research project in the near future.

Mr. Rodulio Caudales, who is an instructor at the Department of Agronomy and Soils, and was assigned by the University to work part-time in the BNF Project, obtained a permit (study leave) to complete his Ph.D program at Rutgers University (Dept. of Biological Science). He left the Project in August, 1982.

During 1982, the principal investigator taught for the second time the Soil Microbiology course (AGRO 407). Nine advanced undergraduates completed the course, with its laboratory aspects stressing Biological Nitrogen Fixation. This course is not required (elective), but is strongly recommended for those students taking the new option in Soil Science.

The teaching of a graduate soil microbiology course in Recent Advances on Biological Nitrogen Fixation is being considered.

Audiovisual material on Soil Microbiology and N fixation has been purchased from IRRI; several slides showing laboratory techniques and experimental results have been prepared and will be useful for teaching, training and conferences.

#### STATE OF THE ART (SOTA) DOCUMENTS

The Mungbean document reviewed for publication by Dr. J. M. Poehlman (University of Missouri, Columbia) was published in March, 1982 and has been distributed locally, to AID Missions and to a list of interested scientists prepared by Dr. Poehlman. Authors Morton and Smith indicated their appreciation for the excellent editing work of Dr. Poehlman.

The Pigeonpeas Sota: "Pigeonpeas (Cajanus cajan Millisp): A Valuable Crop of the Tropics", was published in November, 1982 after

several printing problems and delays at the printing shop (Antillian College Press). Its smaller, new format will help to reduce the distribution costs. Only a partial distribution has been done; it will be further distributed in 1983.

#### AZOLLA WORKSHOP

During the Biological Nitrogen Fixation Workshop at CIAT, Cali, Colombia, in March 1981, a group of scientists, working on Azolla, agreed that there was a need to have a separate meeting dealing exclusively with Azolla in relation to Biological Nitrogen Fixation. The University of Puerto Rico, through its B.N.F. Project and Title XII Strengthening Grant Program, offered its facilities and took the organization responsibilities, through Dr. Eduardo C. Schroder, BNF Project Leader.

In order to help in the organization an International Program Panel was named. Its members were:

#### PROGRAM PANEL

J. K. Becking - ITAL - Netherlands  
 S. Brotonegoro - MALANG - Indonesia  
 Y. Dommergues - ORSTOM - Senegal  
 T. Lumpkin - Univ. Hawaii - USA  
 G. A. Peters - Kettering Res. Lab. - USA  
 I. Watanabe - IRRI - Philippines

It was decided to hold the Workshop from 17th to the 19th of November, 1982.

The Dean and Director of the College of Agricultural Sciences of UPR, Dr. A. Ayala, appointed members to a Steering and an Organization Committee, as follows:

STEERING COMMITTEE

A. Ayala  
P. Meléndez  
L. A. Pico  
E. C. Schroder  
A. Sotomayor  
A. Vélez Ramos

ORGANIZATION COMMITTEE

R. Caudales  
L. M. Cruz Pérez  
J. López Rosa  
C. T. Ramírez  
E. C. Schroder

Since many of the scientists interested in attending were in under-developed countries, additional resources to sponsor their attendance was requested from International Organizations such as FAO, IRRI, UNESCO, IDB, IAEA and IICA, but none of them were able to contribute. Therefore, organizational expenses were covered with monies from the Title XII and BNF Project (USAID), the Puerto Rico Rice Corporation (Secretary of Agriculture) and local private companies.

In response to the First circular mailed to over 1000 persons and institutions, a Mailing List with over 130 interested scientists was organized, and a second circular with information regarding Registration, Accommodations, travel and General Information was sent during June, 1982.

Workshop attendance was approximately 50 persons representing 12 different countries (Surinam; Brasil; México; Dominican Republic; Trinidad; Italy; Belgium; India; Senegal; Sri Lanka; Thailand and USA).

Workshop sessions were held at the amphitheater located at the modern School of Nursing Building. Over 20 research papers, ranging from Basic Azolla studies to applied aspects were presented during the first two days of the Workshop.

On November 19, 1982, a field trip to the rice growing area was held. Different aspects of land preparation, planting and harvesting were demonstrated. After lunch, a tour of the rice mill was conducted.

This field trip was organized very effectively by the Puerto Rico Rice Corporation.

We are now in the process of organizing and editing the papers presented at the Workshop, in order to publish the proceedings.

In summary, the First International Workshop on Practical Aspects of Azolla for Rice Production was a very successful meeting which not only covered current research on morphology, physiology and impacts of Azolla in rice production, but also provided an opportunity to share and exchange knowledge and professional interests. As a measure of this success, scientists attending the meeting will try to organize a second workshop and develop the linkages that were established during this meeting.

#### LINKAGES AND COOPERATIVE ACTIVITIES

In 1981, the Instituto Centro Americano de Investigación y Tecnología Industrial (ICAITI) requested consulting services through AID-ROCAP. Dr. L. R. Frederick (AID/W), indicated that the services of Dr. E. C. Schroder were available. As a result a visit to Guatemala during January 18th to 23rd was undertaken.

The Division of Applied Research of ICAITI, headed by Dr. Carlos Rolz has been working for several years in the field of Biotechnology. They are interested in pursuing the field of BNF and help Central America by developing technology in this field.

The visit included inspection of facilities, presentation of

seminars on BNF and inoculant production, discussion of projects and visits to ROCAP, ICTA (Instituto de Ciencia y Tecnología Agrícolas) and University of San Carlos at Guatemala.

The establishment of a network for research in BNF in Central America was discussed, and ICAITI would submit a proposal to ROCAP to fund such network. A meeting coordinated by ICAITI of all those interested in the network to be held in December, 1982 was postponed, since the expected funding from the Government of Guatemala was not obtained. A preliminary proposal entitled "Studies of Alternative Carriers for Inoculant Production in Guatemala" was submitted to the Office of the Science Advisor (USAID), but it was not selected for subsequent stages.

In order to develop BNF capabilities at ICAITI, technical assistance in the form of training work with Rhizobium and consultants in inoculant production technology are needed.

#### Dominican Republic

In response to a letter by Dr. Cesar E. López (Secretaría de Agricultura, Departamento de Investigaciones Agropecuarias) with the purpose of reviewing Research Projects on Biological Nitrogen Fixation, Dr. Eduardo C. Schroder visited the Dominican Republic between July 18 and 24, 1982.

On going and future research projects involving leguminous trees, forage and grain legumes were discussed with scientific personnel from the Secretaria de Agricultura and three of the four Universities with Agronomy Programs. Since the lack of trained personnel is a major limiting factor, a couple of scholarships to work on BNF towards a M.S.

degree at UPR-RUM were offered. Two applications were received at the Graduate Studies Office of UPR during 1982. One of the students was accepted (Mr. José A. Díaz) for graduate studies at the Dept. of Agronomy and Soils to start his program in January 1983.

It is necessary to emphasize the need to establish a well equipped Soil Microbiology laboratory (probably in cooperation between SEA and the Universities involved) to conduct research on BNF and initiate studies to produce inoculants locally. In this sense, the Dominican Republic has the advantage of possessing peat deposits which should be tested as a carrier for Rhizobium inoculants. It is expected that this cooperation between UPR-BNF and the Dominican Republic will continue.

#### Perú and other linkages

In October 1982 a trip to Perú to attend the XI RELAR (Reunión Latinoamericana de Rhizobium) was taken. The meeting was held at the Museo de Historia Natural of the Universidad Nacional Mayor de San Marcos, Lima, and was attended by 81 persons representing Perú, Argentina, Brasil, México, Uruguay, Panamá, Colombia, Venezuela, Chile, Ecuador, Puerto Rico, El Salvador and USA.

The meeting was organized by Dr. José Gomez Carrión of the Universidad Nacional Mayor de San Marcos and sponsored by several organizations including the BNF Program at N.C. State University. The quality of the research and paper presentation varied substantially according to the country. The meeting help to consolidate the ALAR (Latin American Association of Rhizobiologists); its bylaws were approved and a new Executive Cte. was elected. A very useful Directory of Latin American Rhizobiologists was distributed. The need to update the publication of

"Noticias" now that Rhizobium Newsletter is no longer published was discussed BNF-UPR collaboration was offered.

The meeting was a good opportunity to initiate and strengthen linkages between UPR and Latin America, and several requests for information, strains and seed were received and already processed. Brasil was chosen as the country responsible for the next RELAR (XII), to be held in 1984.

#### BNF and INTSOY

The Soil Microbiology Laboratory facilities at UPR-RUM are being used by the two USAID sponsored programs (BNF/UPR and INTSOY/UI), resulting in a very fruitful cooperation and mutual strengthening relation between the principal investigators and technical personnel of both projects. The contract between UPR and INTSOY/UI has been changed in that INTSOY is now bearing the full cost of the Plant Breeding and Soil Microbiology research programs. Since INTSOY is in the last portion of their AID Contract and funding level at a minimum, INTSOY is having to resort to rather drastic measures to maintain an active program. These cut backs will severely affect the Rhizobium research in Mayaguez especially when the 211D-BNF grant ends in December, 1983.

#### MEETINGS AND TRIPS

In 1982, the principal investigator attended the following meetings:

1. BNF Consortium Representatives Meeting, Technological Assessment of BNF Panel Sessions. Visit to NIFTAL January 10-15, East-West Center and NIFTAL Project, University of Hawaii.
2. Guatemala - Consulting Services. January 18-23. ICAITI-ROCAP, Guatemala City, Guatemala.
3. BNF Limiting Factors Workshop - February 22-23 - Washington, D.C.

4. Dominican Republic - Technical assistance request. July 18-25  
Santo Domingo, Dominican Republic.
5. XI RELAR (Reunión Latinoamericana de Rhizobium) October 24-29,  
Lima, Perú.
6. SOPCA - (Sociedad Puertorriqueña de Ciencias Agrícolas) November  
5. Aguadilla, Puerto Rico.
7. Practical Applications of Azolla for Rice Production (Workshop)  
November 17-19. Mayaguez, Puerto Rico.

#### OTHER ACTIVITIES AND ACHIEVEMENTS

The principal investigator, as a staff member of the University of Puerto Rico, participated in Departmental and regular faculty meetings. He was also elected as a member of the Curriculum Committee, which is studying the option in Natural Resources to be offered by the Agronomy and Soils Department.

In addition to being the Chairman of three graduate students committees, the P.I. is a member of the graduate committees of Astrid V. Mendez, graduate student of Marine Sciences; and María del Carmen Velez of Crop Protection. He also served as graduate studies representative in final exams for M.S. degrees. He is also advising a graduate student (Elsie Carrillo) of the Agronomy Dept., who is working on liming effects with Phaseolus vulgaris in two acid soils.

In order to establish a permanent research group in BNF at the University of Puerto Rico the following proposals and preproposals were prepared and submitted during 1982.

<u>TITLE</u>	<u>SUBMITTED TO</u>	<u>STATUS</u>
1. Effect of lysogeny on the nodulation, N <sub>2</sub> fixation and saprophytic competence of <u>Rhizobium japonicum</u> .	USDA/SEA-CRGP	not approved
2. Studies of alternative carriers for inoculant production in Guatemala	AID/Science Advisor Office	not approved
3. Indigenous Tropical Legumes and their relationship to BNF and small-holder farmers.	AID/Sci A. Off	not approved
4. Nodulation status of leguminous trees and shrubs in Puerto Rico	USDA/M-S	pending
5. Biological Nitrogen Fixation in <u>Phaseolus</u> species	USDA/TUPF	pending
6. Effect of soil pH and host genotype on the nodulation and nitrogen fixation of <u>Leucaena</u> spp.	USDA/TAD	pending

In 1982, the BNF Project improved its Laboratory facilities and equipment by the acquisition through University funds of a gas chromatograph. It is a Perkin-Elmer model Sigma 4B and has been prepared (gases, column, etc.) to determine nitrogenase activity by the acetylene reduction method and was placed in a separate small room. Recently, hardware parts of an APPLE II computer system were received, and when completed with the appropriate software, will be used for word-processing, data storage, statistical analysis and equipment control if necessary.

#### PUBLICATIONS

Schröder, E. C. and Gaztambide, M. A. 1982. Results of an INLIT trial with Leucaena leucocephala. In: Proceedings of the XI RELAR, Lima, Perú, October 1982.

APPENDIX

## PROJECT PERSONNEL

<u>STAFF</u>	<u>POSITION</u>	<u>MONTHS SERVED</u>
Rodulfo Caudales	Instructor*	1-82 - 7-82
Myrna A. de Gaztambide	Research Assistant	1-82 - 12-82
Marfa A. Pagan	Secretary	1-82 - 12-82
Miguel Rivera	Laboratory Aid	1-82 - 12-82
Eduardo C. Schroder	Project Leader, Microbiologist	1-82 - 12-82

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\* Paid with University of Puerto Rico (Mayaguez Campus) funds

LIST OF VISITORS TO THE BNF PROJECT DURING 1982

<u>NAME</u>	<u>INSTITUTION</u>
Gary W. Akin	Tennessee Valley Authority
Nancy W. Axinn	Michigan State University
J. L. Brewbaker	University of Hawaii
Donald G. Faris	ICRISAT, India
Robert H. Gibson	Tennessee Valley Authority
R. H. Howell	Univ. of Illinois
Joe Jackobs	Univ. of Illinois
H. Kauffman	Univ. of Illinois/INTSOY
Hans-Henning Mundel	Agriculture Canada, Canada
Agronomy Dept. Review Team	(several members)
INTSOY Review Team	(several members)