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Research into the Rhizobium/Leguminosae symbiosis in Latin America

Investigación sobre la simbiosis Rhizobium-Leguminosa en América Latina

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Abstract More than 60 institutions and 100 researchers were involved in Rhizobium research in 1978 in Latin America. Half of these researchers were located in Argentina and Brazil. Research activity and the application of research findings vary widely among countries.

Problems that plague research include 1) inadequate training of research personnel and insufficient attention paid to the Rhizobium/Legume symbiosis at agriculture schools; 2) poorly-established research priorities that do not sufficiently weigh the immediate needs for the farmers such as the identification of limiting environmental factors (*e.g.* nutritional deficiencies), techniques for small-scale inoculant production, and quality control of available inoculants; 3) isolation of the researchers and a lack of adequate library support; 4) poorly integrated research teams (*e.g.* in many institutes researchers are either microbiologists with no agricultural background or agronomists lacking microbiological training); and 5) insufficient dissemination of research findings.

Problems with inoculant production and control include 1) a local dependence on national or imported inoculants rather than on locally-selected strains, 2) poor inoculant quality control which results in low inoculation success rates and subsequent discredit to the inoculation practice, and 3) high prices for inoculants.

Extension problems include 1) lacking or deficient legume-promotion programs by government agencies, 2) poor contact between research and extension workers, and 3) administrators, leaders, extension workers and agronomists working in the field that lack adequate knowledge of the Rhizobium/Legume symbiosis.

Immediate measures to foster extension and legume promotion programs and informal and/or official quality control are needed in Argentina, Uruguay, Brazil, Mexico, and probably Colombia. Countries where combined efforts should primarily be directed toward stimulating research and extension include Peru, Venezuela, Costa Rica, and Chile. In Ecuador, Paraguay, Bolivia, Nicaragua, Honduras, Guatemala, the Dominican Republic and Panama, priority should be given to research. Colombia should also be included in this group as national research institutions need to be strengthened. Table 2 lists these priorities more fully.

Resumen Más de 60 instituciones y 100 investigadores están trabajando de la investigación con Rhizobium en América Latina. La mitad de los investigadores están localizados en Argentina y Brasil. La actividad de investigación y la aplicación de los conocimientos científicos varían ampliamente de acuerdo con los paises.

Los problemas de la investigación incluyen: 1) Entrenamiento inadecuado de los investigadores y poca atención para la simbiosis Rhizobium/Leguminosas en las escuelas de Agronomía; 2) investigaciones de baja prioridad sin consideración para las necesidades más inmediatas para los agricultores tales como identificación de los factores limitantes ambientales (por ejemplo: deficiencias nutricionales), técnicas para la producción de inoculantes en pequeña escala y poco control de calidad de los inoculantes disponibles; 3) aislamiento de los investigadores e insuficiente apoyo de

literatura; 4) baja interdisciplinaridad en las investigaciones (por ejemplo: en muchas instituciones los investigadores son microbiológos sin conocimientos de agronomía, o agrónomos sin entrenamiento en microbiología y 5) insuficiente diseminación de los conocimientos científicos.

Los problemas de la producción y control de inoculantes incluyen: 1) las cepas empleadas en los inoculantes (nacionales o importadas) no son seleccionadas localmente; 2) poco control de calidad de los inoculantes y como resultado, inoculantes malos traen descrédito para la práctica de la inoculación, y 3) precios muy altos de los inoculantes.

Los problemas de la extensión incluyen: 1) falta o deficiencia de los programas de promoción de leguminosas por las organizaciones gubernamentales, 2) poco contacto entre los investigadores y los extensionistas y 3) administradores líderes, extensionistas y agrónomos que trabajan en el campo no poseen adecuados conocimientos sobre la simbiosis Rhizobium/Leguminosas.

Algunas medidas inmediatas para promover la extensión y programas de promoción de las leguminosas y/o control oficial de la calidad de los inoculantes son necesarias en Argentina, Uruguay, Brasil, México y posiblemente Colombia. Perú, Venezuela, Costa Rica y Chile necesitan esfuerzos combinados dirigidos prioritariamente para promover la investigación y extensión. En Ecuador, Paraguay, Bolivia, Nicaragua, Honduras, Guatemala, República Dominicana y Panamá, la prioridad debe ser dada para la investigación. Colombia debe ser incluída en este grupo por la razón de que las instituciones nacionales deben ser fortalecidas. La tabla 2 relaciona estas prioridades con mas detalles.

Introduction

Many cereals such as corn (*Zea mays*) can attain much higher levels of high-protein productivity than can legumes. However, high cereal productivity is dependent upon the use of nitrogen fertilizers, while this is not the case for leguminous crops in symbiosis with Rhizobium. This advantage of legumes is of great importance for developing countries with limited energy resources.

Legume cultivation has been little exploited in relation to potential production in these countries, despite the fact that production could meet the rising demand for protein over much of the world at a lower cost than could cereal production. Legumes, however, present special cultivation problems that are not encountered with cereals. Legumes must be matched with the right Rhizobium symbiont, and for high productivity, nutritional and environmental requirements of host and symbiont must be met.

Rhizobia-legume research in Latin America

In 1978, the Porto Alegre Microbiological Resources Centre (MIRCEN) Project began to assemble information concerning the Rhizobium/Legume symbiosis in Latin America. A questionnaire to more than 60 institutions and other sources[1,2,3,6] was used for this compilation, summarized in Table 1. Major research efforts in the region are concentrated in the following countries.

Argentina

Legumes play a large role in the economy of Argentina and in the national diet. Alfalfa (*Medicago sativa*) is the largest legume crop, with over four million ha devoted to its growth, and is the main basis of beef production together with

Table 1. The status of Rhizobium/Legume research and application in Latin America in 1979

Feature	Argentina	Chile	Uruguay	Brasil	Paraguay	Bolivia	Ecuador	Peru	Colombia	Venezuela	Costa Rica	El Salvador	Nicaragua	Dominican Rep.	Mexico	Guatemala	Panama
Institutions	11	4	2	14	nd	4	nd	3	3	5	1	2	0	nd	5	nd	1
Researchers	35	7	7	35	nd	4	nd	5	20	5	1	3	0	8	12	nd	2
Inoculants																	
production																	
public	+***	+	+	+	–	–	–	+	+	–	–	–	nr	–	–	–	–
private	+	+	+	+	–	–	–	–	–	–	–	–	nr	–	+	–	–
importation	+	+	–	–	+	+	+	+	+	nr	nr	nr	nr	–	+	nr	nr
quality control																	
informal	+	+	+	+	–	+	–	+	–	–	–	–	–	–	+	–	nr
official	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	nr
acceptance*	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
intensity of use	L	L	H	H	nr	nr	L	L	L	L	nr	nr	nr	nd	L	nr	nr
Legume importance																	
economic	H	L	H	H	H	L	L	L	L	nd	nd	L	L	L	L	L	nd
dietary	H	M	H	H	H	L	L	H	M	nd	nd	nd	nd	nd	nd	M	nd
Important legumes**	1,2,3,4	1,3,5	3,1	2,8,6	2,7,6	1,8	8,4	8,4,1,3	8	7,8	8	8	8	8	8,1	8,4	nd

* inoculation accepted by farmers and widespread

** 1, alfalfa; 2, soybeans; 3, clovers; 4, peas; 5, lens; 6, peanuts; 7, cowpeas; 8, beans.

*** +, present; –, absent; nr, no record; nd, not determined; H, high; M, moderate; L, low.

clover. Soybeans, planted to 1.5 million ha, are the second largest legume crop, followed in importance by peanuts (*Arachis hypogaea*), beans (*Phaseolus vulgaris*), peas (*Pisum sativum*), and lens (*Lens esculenta*) among the grain legumes. In spite of the importance of legumes and the fact that there are nine inoculant factories in Argentina[4] as well as many institutions and researchers that have long worked on Rhizobium, the use of inoculants by farmers is relatively low.

According to available information, Argentina was the first Latin American country to begin Rhizobium research. Around 1940 the 'Unitad de Symbiosis' was established at the Instituto Nacional de Technologia Agropecuaria (INTA) near Buenos Aires, under the leadership of Enrique Schiel, who retired 10 years ago. The main activities of the Unidad de Symbiosis, still the main institution for this work, include the selection of efficient Rhizobium strains, research on the effects of pesticides, and the production of inoculants (on agar) for grain and forage legumes.

Another group is working in northern Argentina at the Universidad del Nordeste in Resistencia; their main activity is the production of peat inoculants. At the Faculdad the Ciencias Exactas, Universidad de La Plata, a dynamic group works on technological aspects of inoculant production. Activity has recently been started at the Universidad de Rio Cuarto and at the Universidad de Cordoba, as well. Another long-established group has been working sporadically on Rhizobium at the Universidad de Buenos Aires, Catedra de Microbiologia. At the same university, a new group working on forage research is informally evaluating the quality of inoculants for forage legumes. This is the only place that evaluates inoculant quality.

Chile

Chile has a low-density population, beef production is low, and seafood is an important source of protein. However, temperate grain legumes such as peas, lens and chickpeas (*Cicer arietinum*) are also important in the Chilean diet and alfalfa and clovers (*Trifolium* spp.) are important pasture crops.

Chile also has a long-standing tradition of Rhizobium research. Research started at the Universidad de Concepcion in southern Chile, by Luis Longeri, who is still actively leading a small group. Other researchers are working on Rhizobium at the Universidad Tecnica del Estado, the Universidad Catolica de Chile, and the Instituto de Investigaciones Tecnologicas in Santiago. Of these, the Universidad Tecnica del Estado program is the most comprehensive.

Small-scale production of inoculants was started at the Universidad de Concepcion in the 1960's and production continues there and at a private company. Quality control is performed on an informal basis by two university laboratories.

Uruguay

Pastures and forage production are very important parts of the Uruguay economy, which is based on beef and wool production. Plan Agropecuario was successfully established around 1962 to improve agricultural production. The program included an FAO-supported laboratory for Rhizobium research and for checking the quality of inoculants. The national leader was Carlos Batthyany who, together with Richard Date from Australia, succeeded in establishing active programs of research, extension and cooperation with inoculant factories. The leader of this group is now Carlos Labandera. Another group, led by Gloria M. de Drets, is researching the biochemistry and physiology of Rhizobium at the Instituto de Investigaciones en Ciencias Biologicas.

Inoculants have been used both extensively and intensively for establishing pastures of clovers, *Lotus* and other temperate legumes, mostly on soils with no native Rhizobium. Inoculants from the two private factories have been controlled since 1963 by analyzing the broth and the final product according to government regulations.

In 1964, Uruguay researchers promoted the first Latin American meeting of rhizobiologists (RELAR). Since then the meeting has been held without interruption in different countries of the region, initially every year but now every two years.

Brazil

General In economic terms, by far the most important legume in Brazil is soybeans (*Glycine max*), planted mostly in the south of the country to over twelve million ha. Common beans (*Phaseolus vulgaris*) are planted to smaller areas than soybeans but are very important since they are a major part of the every day diet for many people with low incomes. Cowpeas are also an important part of the diet in the northeast. Peanuts are grown in the State of Sao Paulo, mostly for oil production. Temperate forage legumes such as clovers, alfalfa and *Lotus* are important in southern Brazilian pastures, and tropical legumes such as perennial soybeans (*Glycine max*), siratro (*Macroptilium atropurpureum*), centrosema (*Centrosema pubescens*), and others are important in the southeast.

Around 95% of the inoculant produced in Brazil is for soybeans. In 1980, Brazil's six inoculant factories produced over six million 200 g packages of soybean inoculant, which means that around 30% of the total soybean seed was inoculated. More than 50% of soybean seeds were inoculated in areas where the crop was expanding rapidly, and it is reasonable to assume that inoculation helped with the expansion and subsequent crop productivity. If it is assumed that nodules make a modest contribution of 50 kg N ha^{-1} planted to soybeans, at the present price of mineral nitrogen (US\$0.70 kg^{-1} N), Rhizobium-soybean nitrogen fixation is equivalent to 420 million dollars of nitrogen per year.

Inoculation is also used for temperate forage legumes in the State of Rio Grande do Sul and for some tropical forage crops, mostly in the states of Sao

Paulo and Parana. Peanuts and beans are rarely inoculated. Both are usually grown by poorly-educated farmers on small farms, though peanuts are said to fail to respond to inoculation and beans to respond erratically in field experiments. The price of Rhizobium inoculants in Brazil is very low compared to prices in other countries; it has been the government's policy to promote the large-scale use of inoculants since the first inoculant factory started production.

Effective work on Rhizobium started in Brazil at the Biological Institute of the State of Sao Paulo in 1947 by Julio Amaral. Interest at other institutions soon arose and the groups grew stronger with the growing importance of soybeans and the greater interest in pasture legumes. One such group is at Rio de Janeiro, EMBRAPA (km 47), under the leadership of Johanna Dobereiner, and the emphasis of its research program is on associative N_2-fixation in grasses. Another group is based at Piracicaba, in the State of Sao Paulo, under the leadership of Alaides Ruschel, and this group works mostly on common beans and soybeans. Yet another strong group is based at Campinas under Eli Lopes, and works mostly with peanuts and tropical forage legumes. A group also works at the Cerrado Research Center of EMBRAPA in Brasilia, and a new group has formed at the University of Vicosa, Minas gerais State. Other researchers are scattered in different institutions; 35 researchers in Brazil are presently engaged in Rhizobium work.

The IPAGRO/UFRGS group In 1949, pressed by the demand for inoculants by the growing number of soybean farmers, I started a program of strain collection, strain selection, and the small-scale production of inoculants first on agar and then in peat powder at the Agronomic Research Institute of the State of Rio Grande do Sul (IPAGRO). The group grew and merged with the staff of Soil Microbiology of the Department of Soil Science of the University of Rio Grande do Sul, and now nine scientists direct the group's research, culture collection, inoculant production, inoculant quality control, and training and extension programs.

The major objective of the research program is to select effective and competitive strains of Rhizobium for legumes of economic or experimental importance. Eighty-four of the 650 strains in the Rhizobium collection are from threatened collections (O. N. Allen's of the University of Wisconsin and L. B. Erdman's of the U.S. Dept. of Agriculture). More than 100 strains have been recommended for inoculant manufacture, and since 1956 the majority of the inoculants produced by private industry in Brazil have used strains supplied by the IPAGRO Laboratory. With the establishment of MIRCEN in 1978, the culture collection has undergone reorganization in order to better characterize and preserve inoculants and to better dissiminate the information gathered.

The research program also includes the search for a strain of *R. phaseoli* that is tolerant to stress conditions, the identification and evaluation of soil factors that limit successful inoculation, the evaluation of the need for inoculation in some

Table 2. Promotional needs for Rhizobium/Legume use in Latin America. Visiting consultants are important for all categories

Need	Argentina	Chile	Uruguay	Brazil	Paraguay	Bolivia	Ecuador	Peru	Colombia	Venezuela	Costa Rica	El Salvador	Nicaragua	Dominican Rep.	Mexico	Guatemala	Panama
National institutes*					x	x	x		x***		x		x	x		x	x
Training programs					x	x	x	x	x		x		x	x		x	x
Inoculants																	
production						x**		x	x	x		x			x		
Quality control																	
informal	x	x		x		x			x	x					x		
official	x	x													x		
National workshops																	
and seminars	x	x	x	x				x	x	x					x		x
Culture collection																	
improvement	x	x	x	x		x		x	x	x					x		

* strengthening of research capability.

** initiated production of laboratory inoculant in late 1978.

*** CIAT responsible only for *P. vulgaris* and tropical forage legumes; national institute necessary for other legumes.

tropical forage legumes, and examination of inoculant-application technology (see Mircen[5]). For many years, Rhizobium-soybean research has been emphasized. Emphasis is now changing to include common beans and alfalfa and other forage legumes.

The IPAGRO Laboratory also supplies inoculants to researchers and experiment/demonstration stations directly in order to encourage research and extension work. This service has contributed significantly to the dissemination of inoculant information. The IPAGRO team has helped the private inoculant industry in Brazil since the industry's start in 1956 by supplying technological advice, informal quality control, and personnel training in addition to selected strains of Rhizobium. Microbiologists at four of the most important companies were trained at IPAGRO laboratories.

Since 1977, on behalf of the federal Ministry of Agriculture, the IPAGRO Laboratory has been in charge of official quality control for inoculants produced in Brazil or imported. This is in accordance with a 1975 law that regulates the production and trade of legume inoculants. The law established a minimum standard and requires that all inoculants contain only Rhizobium strains recommended by the official laboratories. This assures that the strains that are produced by the inoculant factories and subsequently used by the farmers are strains selected at research institutes. Before 1975 inoculant quality was maintained only by informal quality control carried out by laboratories cooperating with factories and examining samples collected at markets and from farmers.

Inter-regional cooperation in the Rhizobium field became a working objective of the group with the establishment of MIRCEN. The training program has been formalized, the culture collection improved, and the inoculant/technology program expanded in order to cover all other countries in Latin America.

Developing a regional research capability has been one of MIRCEN's high priorities. In 1979 and 1980, 45 microbiologists from 13 countries were trained in applied Rhizobium technology *via* 2 short formal courses plus internal practical training. Others have been trained before 1979 and during the regular course for the M.Sc. degree at the Department of Soil Science. These researchers will undoubtedly benefit their institutions of origin, especially those in countries where previously little or no Rhizobium research was performed (*e.g.* Bolivia, Ecuador, El Salvador, and the Dominican Republic). An additional objective of the training program is to train administrators and extension workers. There are few agronomists in the extension services and experiment stations that have adequate knowledge of the benefits of the Rhizobium/legume symbiosis.

Disseminating information to Rhizobium workers in the region is another objective of MIRCEN; this helps to break scientific isolation and stimulate cooperative research. General newsletters, special research bulletins containing suggestions for research, and a culture catalogue have been issued and distributed to workers in the MIRCEN network.

Funding for the activities of the group comes from national sources for the research, inoculant production, and inoculant quality-control programs. The culture collection, training activities, and publication programs are supported by UNEP.

Paraguay

Soybeans are the most important grain legume in Paraguay (400,000 ha planted to soybeans in 1979), and the grain produced is almost totally exported. Cowpeas and peanuts are the main sources of protein for the poor people in rural areas. Forage legumes are rarely grown. There is no Rhizobium research activity nor are there inoculation trials, and so far there has been no success in attracting personnel for training at MIRCEN. Inoculants for soybeans are imported from Brazil.

Bolivia

This country has a low population density and a relatively high availability of animal protein. Consumption of legumes as a source of proteins is thus low. However, soybean cultivation is expanding at a high rate (15,000 ha planted to soybeans in 1976 *vs* over 100,000 ha in 1980). Alfalfa is traditionally used for hay and in pastures but no data on the actual extent of its use are available.

Rhizobium research in Bolivia has started only recently. The Universidad de Santa Cruz de la Sierra in connection with the FAO/UNDP/BOL. Abapo Izozog Project for the Development of the Bolivian Chaco has a soil specialist trained by MIRCEN who expects to undertake the small-scale production of inoculants. At both the Universidad de Chochabamba and the Research Station there is interest in starting work on Rhizobium.

Ecuador

Grain legumes play an important role in the supply of protein to people in Ecuador, although the roles of maize and wheat are more important. The potential for cropping forage legumes has yet to be exploited. There is enthusiasm for soybean research and a good research program exists, though on an Rhizobium/legume research there is little activity apart from an occasional inoculation trial. Inoculant is imported. The government has proposed a factory for inoculant as part of a larger special program for the development of grain legumes for human consumption, but trained personnel are lacking.

Agricultural research institutions are well equipped and have qualified personnel. Two researchers from the INIAP S. Catalina Experiment Station have been trained at MIRCEN, and research is being initiated there.

Peru

Of all Latin American countries, Peruvians have the highest per capita consumption of legumes in the human diet. Grains of many temperate and

tropical legumes are consumed. Pasture legumes are important both in the mountains and in the tropical lowland regions of the Amazon. Soybeans have been recently introduced and their cropped area is expanding rapidly. Seed inoculation, however, is not a common practice.

Rhizobium research is presently under way at two centers. One is at the Universidad Nacional Mayor de San Marcos in Lima, where a staff of one M.Sc. trained Agronomist and two technicians are performing strain selection experiments and starting a project to produce a peat inoculant. The other center is at the Universidad de San Cristobal de Huamango, Ayacucho, where a small team of professionals is producing a peat inoculant. Laboratory facilities in Lima are adequate, but no greenhouse is available. In Ayacucho, facilities are poor to medium. There is no private inoculant production and no official or informal quality control of the imported inoculants. There is little if any contact among researchers and extension workers. There are also restrictions on the work undertaken due to scarcities of funds and of trained personnel, although three researchers from the University of San Marcos and one from Ayacucho have attended MIRCEN training courses. Dissemination of available information among extension workers and farmers is poor.

Due to the importance and potential of legumes in Peru, efforts are being made to develop Rhizobium work. In 1980 the FAO/Biological Nitrogen Fixation (BNF) Project sent Carlos Batthyany on an advisory visit to Lima, and in 1981 the USAID-BNF Program offered a training course for extension workers and administrators.

Colombia

Cowpeas and common beans are probably the most important grain legumes in Colombia, but the cropped areas are not large. Soybean is being promoted and the area planted to this crop is expanding.

The availability of Rhizobium strains and inoculants for experimental use in the country is good due to research activities at CIAT. Nevertheless, this international institution works mainly on tropical forage legumes and common beans. Work by nationals is being conducted by a small group at the National University of Colombia under the leadership of Nery Gonzales, and includes two researchers trained at MIRCEN. At Palmira Institute, inoculation trials are run by Varella, also trained at MIRCEN. Some inoculant is imported but there is no quality control.

Venezuela

Protein production within Venezuela is insufficient for the needs of the population. Beef, soybeans, chickpeas, dry beans and lentils are imported. Nitrogen fertilizer is subsidized and applied at high rates on pastures, which also receive large doses of leaf herbicides which kill the abundant native tropical forage legumes.

Some research on Rhizobium is under way at Faculdad de Agronomica, UVC, in Maracay, at CENIAP in Maracay, at Facultad de Agronomia in Maracaibo, and at IVIC in Caracas. There is hope the the Tenth Latin American Meeting on Rhizobium (RELAR) held in September 1980 at Maracay will result in increased attention for Rhizobium/Legume work in Venezuela.

Mexico

The human diet in Mexico is based on maize. However, dry beans are also important and large areas are planted to alfalfa for milk production. Soybean production is expanding rapidly.

Before the Ninth RELAR held in Mexico in 1978, there were only two centers working with Rhizobium. One is at the Departmento de Microbiologia, IPN, where a group has long been working under the leadership of Maria Valdes. The second group works at Fertilizantes Mexicanos S.A., a government enterprise. The Ninth RELAR awoke great interest in biological nitrogen fixation and now eight other centers are working with Rhizobium. A private company produces inoculants but the quality control is thus far informal and many problems related to the quality of the inoculants have occurred.

Other countries

More interest in Rhizobium has developed in Central America during recent years; work is currently underway in Costa Rica, El Salvador, Guatemala and Panama. Nine researchers from Central America and Mexico have been trained at MIRCEN. Common beans are important everywhere in the region and are the staple food in many areas. In the Dominican Republic, interest in Rhizobium is recent but is developing quickly; two researchers have been trained at MIRCEN.

Legume inoculation is apparently low in all Central American and Caribbean countries except Mexico. This region can greatly benefit from research at the University of Puerto Rico where a staff of three under E. Schroeder have developed a strong research program in connection with USAID-BNF and INTSOY.

Regional meetings

The Latin American Meeting on Rhizobium (RELAR) has had and continues to have an important influence on Rhizobium research in the region. Ten meetings have been held since 1964: in Uruguay (1964, 1971), Argentina (1965, 1974), Chile (1967), Brazil (1968, 1970), Colombia (1976), Mexico (1978) and Venezuela (1980). There has been an upsurge of interest in biological N-fixation research and its application in the host countries. Attendance has been growing since the first meeting, which attracted 15 participants; at the Mexico RELAR there were 150 participants. Though many of these participants were students, this nonetheless indicates growing interest in this area at the universities. An

unwritten policy of the RELAR organization committee is to select host countries that could benefit from the resulting attention paid to Rhizobium work.

The Latin American Association of Rhizobiologists (ALAR) was created at the 1964 RELAR in Porto Alegre, and since has been coordinated by Carlos Batthyany. The Association had no formal structure until the Tenth RELAR.

International cooperation

A number of international programs promote cooperation among researchers and institutions in the region:

1. The NIFTAL/Univ. of Hawaii/USAID Project offers training opportunities via short courses and internal practical training, selected Rhizobium strains, bibliographic services, and laboratory manuals. Additionally, a network of cooperative experiments has been established for research on tropical legumes.

2. CIAT in Colombia offers opportunities for internal practical training, selected Rhizobium strains, bibliographic services, inoculants for experimental use, and the 'Noticias' newsletter with a bibliography of great value to the researchers. An international network of experiments with common beans has been established as well.

3. The U.S.-AID/Biological N-Fixation (BNF) Consortium includes the Universities of Cornell, North Carolina, Hawaii and Puerto Rico in a BNF program for the tropics that offers training courses and operates mainly through the NifTAL and Puerto Rico Projects.

4. The FAO/BNF Project, based in Rome, is directed at forage legumes and has extension-oriented objectives. Demonstration experiments have been established in Mercedes, Argentina, and in Pucalpa, Peru.

5. The UNEP/UNESCO/ICRO-MIRCEN Project based at Porto Alegre, Brazil, offers training opportunities *via* short courses and internal practical training, selected Rhizobium strains, inoculants for experimental use, inoculant quality control, bibliographic services, and grants for research and libraries to some key laboratories of the region. A regional network for evaluation of soybean Rhizobium strains is being established, and a network for alfalfa strains is being planned.

Coordination, exchange of information, and cooperation among the different institutions and projects that are involved in Rhizobium work will greatly facilitate the general objective of promoting Rhizobium nitrogen fixation in the region.

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