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**EXPERT REPORT  
PREPARED BY PROF. D. LE RUDULIER**

CLT 89/570

Caracas, Venezuela, 10-14 December 1989.

**Duties :**

- Discuss with Andean Development Pact Promotion of joint UNIDO/CAF Initiative on Production of high value added secondary metabolites of industrial importance through tissue culture of tropical plants.
- Assess existing laboratory infrastructure
- Identify laboratories in different countries of Pact that would be involved in initiative.

During my mission to Caracas I was received by Mr. Marcello TEJADA, Adviser to the Executive President of CAF. He had perfectly organized the maximum visits of Institutions within the allowed time and gave me spontaneously the informations needed.

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## **I.- INTRODUCTION**

The "Corporacion Andina de Fomento", CAF, (= The Andean Development Corporation, ADC) is a financial Institution of the Andean Group, which is made up of Bolivia, Colombia, Ecuador, Peru and Venezuela. The Corporation was established as a legal entity under international law on February 7, 1968 by representatives of its member nations.

The Corporation's activities are controlled by the Shareholders Assembly, the Board of Directors, the Executive Committee and the Executive President. CAF's headquarters are located in Caracas, Venezuela. The Corporation also has representative offices in Bolivia, Columbia, Ecuador and Peru.

CAF's financial resources are loaned out to member nations for priority projects in physical infrastructure, industry, agriculture, transportation, telecommunications, mining, energy, pre-investment, services and other areas. The Corporation has several areas of activities. It works as a Development Bank, an Investment Bank, a Foreign Trade Bank and a Project Promotion Agency.

As a Project Promotion Agency, CAF carries out studies aimed at identifying new investment opportunities which benefit the Andean Group. It also provides technical and financial assistance for the planning and execution of binational and multinational projects, helps to obtain capital and technology for these projects, and aids in organizing, expanding, modernising and reorienting companies.

CAF encourages private investors to participate in the establishment of Andean multinational companies and to strengthen trade within the Andean subregion. This is done through contacts with binational chambers of commerce and with business organizations in each member nation. At the same time, it provides grants to businessmen and organisations so that they can carry out pre-investment studies for new projects.

The Biotechnology Program seeks to attract the skills of the Andean scientific and research community for applying biotechnology to the health and productive sectors.

## **II.- THE BIOTECHNOLOGY PROGRAM**

The Andean Biotechnology Program (ABP) has three basic areas of activity : specific projects, industrial development and training.

### **1. Objectives**

The purpose of this program which begun on January 1988 is to promote biotechnology related specifically with the development of the agricultural and food sectors of the countries in the Subregion through supporting research and industr

The program's specific goals are :

- To contribute in the improvement of quality and productivity of basic cultures to feed the region's population.
- Promote communication among research centers encouraging systematic exchange of biotechnological data.
- Support development of specific research projects of application and production with the criteria that in the future these centers will be self-funded.
- Encourage through financial and technical assistance the creation of companies specialize in modern biotechnological products for the improvement, expansion and marketing of plants, agricultural and food production.
- Support the creation of operative structures that will integrate the research sector and the consumers.
- Organize programs to capacitate personnel and facilitate the exchange of information in the region.

The ABP includes two lines of operations :

- Research activities applied and production, designed to promote and utilized the ressources available in the subregion using technologies that could be transferred or acquired in a short term. Fundamentaly, it will include the micromultiplication of agricultural species, with a social and commercial interest with the intention of suppling this high quality vegetative material to all the agroindustrial sectors of the subregion. The CAF will asign most of the funds to these line of projects.
- Activities destine to enhance their biotechnological knowledge and strengthen the research structures of the subregion.

The primary objectives for using this policy are :

- To reduce technological differences in existence with industrialized countries or find a way to keep them within reasonable limits.
- Favored a balance biotechnological development among the countries of the subregion.
- Achieved in a short time sufficient capability to allow theses countries to solve their problems.

## **2.- Activities**

The activities accomplished during 1988 and 1989 can be divided in four groupes: organization and administration, training and transferring of technology, specific projects and industrial development.

### **a.- Organization and Administration**

These efforts have been directed to structuring administrative guide lines that will permit proper management and control of the funds as well as accurate operation of the projects and other scheduled activities of great importance is the elaboration of the law to administrate the Andino fund of Biotechnology. A resolution of the executive presidency authorized the members of CAF in these countries to administrate and control the funds, collaborate evaluating and supervising the activities of the projects.

In addition, agreements of cooperation were signed with domestic and international institutions of science and technology, like the International Potato Center (C.I.P.) with headquarters in Peru and the International Center of Tropical Agriculture in Cali, Colombia. They also agreed to collaborate with the Regional Program of Biotechnology of the United Nations. All these treaties will lead to assured the coordination of the programs and the evaluation of research and training activities.

It was also discussed, with the foreign relations departments of the countries, the need to exempt material and equipment required by the Corporation to be used conveniently in the research centers involved.

### **b.- Specific projects**

Up to December 31, 1988 the CAF has approved financing for 22 research projects in five countries for the amount of US \$ 830,000. In the same period the corporation signed 18 agreements of cooperation not refundable that total US \$ 679,000.

Of the 22 projects, 16 belong to the farming sector, 3 to fermentation, 2 to biomedicine and 1 to agriculture. The following projects are detailed by country.

#### **BOLIVIA (4 projects) :**

**Project 1 :** Production of certified potato seed based on meristematic reproduction

Performed by : Bolivian Institute of Science and Nuclear Technology.

Contribution of CAF : US \$ 18,000.

The International Organization of Nuclear Energy (OIEA) of Vienna contributes financing this project with US \$ 52,000 in equipment.

**Project 2 :** Production of improved clones of Yuca = Cassava = Manioc, based on multiply in vitro technics

Performed by : University Rene Moreno de Santa Cruz.

Contribution of CAF : US \$ 34,000

**Project 3 :** Artificial insemination in lamas to improve its quality and productivity.

Performed by : Genetics Institute of Mayor of San Andres University and IBTA (Bolivian Institute of Agricultural Technology).

Contribution of CAF : US \$ 70,000

**Project 4 :** Immunization and cattle therapy for snake bites; based on monoclonal antitoxins.

Performed by : Immunology Institute of Mayor de San Andres University.

Contribution of CAF : US \$ 50,000

**COLOMBIA (3 projects) :**

**Project 5 :** Micromultiplication of manzano to obtained varieties of high quality.

Performed by : Tunja University

Contribution of CAF : US \$ 35,000

**Project 6 :** Multiplication in vitro of dominican banana and evaluation of its development in the fields (Somaclonal variation).

Performed by : Caldas University

Contribution of CAF : US \$ 68,000

**Project 7 :** Production of Riboflavine (vitamine B<sub>2</sub>) by fermentation technologies

Performed by : Nutribal Industries and Nutrilab Laboratories of Cali.

Contribution of CAF : US \$ 80,000 (Funds of Technical Cooperation).

**ECUADOR (4 projects) :**

**Project 8 :** Micromultiplication of potato for production of certified seed.

Performed by : National Institute of Agricultural Research (INIA)

Contribution of CAF : US \$ 33,000

**Project 9 :** Micromultiplication of sweet cucumber and tomato in order to obtained healthy plants of high performance.

Performed by : Ecuador Central University

Contribution of CAF : US \$ 30,000

**Project 10 :** Production of diagnosis kits for cistercosis.

Performed by : Regional Hospital of the Ecuatorian Social Security Instituto of Guayaquil.

Contribution of CAF : US \$ 60,000

**Project 11 :** Biotechnological studies in shrimp to improve the efficiency indexes.

Performed by : Quito Catholic University and Guayaquil Polytechnic School.

Contribution of CAF : US \$ 30,000

**PERU (6 Projects)**

**Project 12 :** Micromultiplication of sweet potato to obtain high efficiency clones.

Performed by : National Agricultural University La Molina.

Contribution of CAF : US \$ 37,00

**Project 13 :** Bioconversion of agricultural residues to obtain unicellular proteins.

Performed by : National Agricultural University La Molina.

Contribution of CAF : US \$ 20,000.

**Project 14 :** Obtained improved clones of melloco (*Ullucus* sp.) by micromultiplication technologies.

Performed by : National University Mayor of San Marcos.

Contribution of CAF : US \$ 30,000

**Project 15 :** Embryo transfer of alpaca to improve the quality and productivity of farms.

Performed by : Veterinary Institute of Tropical Highs Investigations.

Contribution of CAF : US \$ 34,000

**Project 16 :** Creation of merismatic reproduction laboratory to obtain an improved variety of pineapple using in vitral culture technics.

Performed by : INDALSA Industries.

Contribution of CAF : US \$ 40,000 (Fund of Technical Cooperation).

**Project 17 :** Regeneration of yuca plants originated from cells in order to facilitate the insertion of genes to provide proteins.

Performed by : National University Mayor of San Marcos (UNVISM).

Contribution of CAF : US \$ 30,000



**VENEZUELA (5 projects) :**

**Project 18 :** Vitral potato tubing for production of certified seed.

Performed by : International Institute of Advanced Studies.

Contribution of CAF : US \$ 20,000

**Project 19 :** Germplasm collection and micromultiplication of domestic cocoa to develop new plantations.

Performed by : FONAIIP.

Contribution of CAF : US \$ 26,000 --

**Project 20 :** Obtain varieties of potatoes resistant to cold weather through genetic engineering.

Performed by : Venezuela Central University (U.C.V.).

Contribution of CAF : US \$ 40,000

**Project 21 :** Obtain a diagnosis kit for chagas disease (*Tripanosoma*).

Performed by : Carabobo University.

Contribution of CAF : US \$ 32,000

**Project 22 :** Production of enzymes through genetics transformation of *E. coli*.

Performed by : Venezuela Central University (U.C.V.)

Contribution of CAF : US \$ 12,000

### c.- Industrial Development

A number of technical and marketing studies in the agricultural products areas fermentation and monoclonal antibodies characterization of nucleic acid for diagnosis purposes have been concluded. These studies seek to identified feasible lines of production in industrial projects to be developed at a higher scale.

It's been verified the potential for investment in the biotechnological industry, especially tissue cultures and fermentation. Fifteen products, most of which are not produced in the region, are now the focus of interest for investment by national and international companies.

The following are some of the most important lines that will reach a feasible industrial level.

#### **Multinational Plants :**

- Penicilline plant
- Commercial enzymes plant (amidase, protease, pectinesterase, invertase)

- Monosodium glutamate and lysine plant
- Acetone butanole plant.
- Vitamine B<sub>2</sub> and B<sub>12</sub> plant

***Plants for domestic markets :***

- Yeast and unicellular protein plant for animal food
- Yeast from banana, pulp for stabilizers
- Mushrooms for human consumption
- Microbial rennin
- Acetic acid
- Beta carotene.

In addition some of investment projects have been evaluated and studied. In the biotechnical area, two tissue culture industries in Ecuador and Peru and a plant to produce yeast for human and animal consumption are among the most attractive.

**d.- Training programs and transference of technology**

Complying with the program, the Corporation has organized the following activities :

- The first course in vegetable tissues given at the International Institute of Advance Studies (IDEA) in Venezuela. 21 Technicians from 5 countries were trained in meristematic reproduction technologies.
- Two courses of genetic engineering applied to agricultural products took place at IDEA. 14 technicians from 5 countries participating (Transformations with *Agrobacterium*, preparation of protoplasts, electroporation).
- The first courses in use of electronic equipment in agricultural biotechnology at IDEA. 16 participants.
- Meeting of experts in fermentation in Colombia
- Second Congress of Biotechnology, held in Cali, Colombia.
- More than 30 experts of the region were trained individually through courses and workshops locally and abroad, encouraging, with good results, technical support and transference of technology in the subregion.

Several documents and publications have been produced such as = Technical and Market Research for fermentations products (in Bolivia, Colombia, Peru, Venezuela), Technical and Market Research for monoclonal antibodies (in Venezuela), Agricultural and

Agroindustrial sectors in the Andes Subregion, course in vegetable cultures...

### III.- INSTITUTIONS VISITED IN CARACAS AREA

Three research centers have been visited in Caracas (IDEA, UCV and IVIC) and one in Maracay (CENIAP).

**1.- IDEA = International Institute of Advanced Studies.** (Instituto Internacional De Estudios Avanzados). Located in a large area, outside Caracas.

In this Institute, researchs are conducted in several areas : human biology, animal and plant biology, natural ressources, education and social sciences. Several units of investigations are associated into two main Centers :

- Biosciences center dealing with molecular biology, ultrastructure, cellular biology, neuroscience and biotechnology
- Interdisciplinary Center for theoretical investigations conducting researchs in political sciences, arts, philosophy, geology, physics.

I was introduced to Mr. J. Requeira, Director of IDEA, Leopoldo Villegas and Fernando Angel. Two laboratories have been visited (molecular biology and biotechnology). The visit was conducted by F. Angel who got his doctorat in molecular biology few years ago in France (Lyon).

#### a.- Equipment

Both laboratories cohabit in the same nice and very convenient one floor building. They both have new very good equipment, (mainly the molecular biology lab.) and large facilities. Major communal equipment is present :

- 2 high speed refrigerated centrifuges (Beckman L8) with rotors.
- 2 low speed refrigerated centrifuges (Beckman J21) with rotors.
- 2 scintillations counters (Beckman LS7800)
- lyophiliser
- 80°C freezers
- high performance UV/Vis spectrometer (Beckman DU8)
- growth chamber, shakers and incubators
- cold room
- autoclaves
- tissue culture room with 4 hoods

- 2 electronic transmission microscopes (Phillips PW6585)
- fluorescent microscope
- freeze etching system
- analytical gel electrophoresis system with UV lamps.

In addition to this equipment, two green houses are available.

In conclusion, both laboratories are well equipped. The weak points are certainly the library (very few journals, but I was told that informations can easily be obtained at the University) and the human potential. Only few persons (scientists) are involved and scientific activity seems quite low (personal impression). I was unsuccessful to get any publications !

#### **b.- Scientific project.**

In the biotechnology lab, Dr. F. Angel is in charge of a molecular biology project on Cassava (= yuca = mani oc). 4000 clones of cassava are available from the CIAT (International Center for Tropical Agriculture, Cali, Colombia) ; this collection is called P-IVAG and has already been studied for morphological markers and isoenzymes (esterases...). The project is to develop DNA finger printing techniques which will provide a powerful means to enlarge the portion of the genome that can be analyzed in order to determine genetic stability. The proposed methodology involves :

- short highly repetitive sequences. It is proposed to look at the polymorphism provided by short sequences (50-200 bp) of highly repetitive DNA. Digestions of total genomic DNA will be made with different restriction enzymes and run in a PAGE in a continuous gradient.

- RFLP. Alternatively, RFLP measures the differences in length of different restriction fragments among different genotypes. A genomic library has to be constructed from cassava variety in order to be used as a source of possible probes. Middle repetitive sequences will be selected to detect polymorphism among genotypes.

One objective of this project is the elimination of cyanic acid in cassava.

I agree that this project is indeed an important and attainable objective, and that some progress could be made by this laboratory. However, I recommend the inclusion of other research into the scientific effort since Dr. F. Angel is really alone (at IDEA) dealing with the project.

#### **2.- UVC = University of Central Venezuela**

Two departments were visited :

- Department of cellular biology (and molecular biology)
- Department of Botany.

## a.- Equipment

All the laboratories are located downtown in a quite old building. Generally speaking, the scientific equipment is not new but well kept and efficiently used. In the molecular biology laboratory an important effort has been made to get new powerful instruments.

There is not doubt about the quality of the researchs conducted in both departments but I was really impress by the results obtained in Microbiology (production of enzymes from *E. coli*) and Molecular Biology (DNA analysis of *Leishmania*).

## b.- Scientific projects

### - Cellular biology.

Mr. Angel Hernandez is in charge, with a group of PhD's, of a program on *Leishmania*. They are mainly studied the cytoskeleton, antigenic proteins for vaccin purposes, other receptors and the transformation of the parasite. This group has a strong cooperation (via a full agreement) with the University of Paris VII in France (Institut Jacques Monod). Others cooperative projects involved Perou, Colombia, Bolivia, and an English laboratory in Liverpool. Part of the financial support was obtained from the European Economic Community and the French Government.

This group has a good expertise on *Leishmania* and very beneficial collaboration with several countries.

### - Molecular biology

Mr. José Luis Ramirez is involved in molecular biological studies of *Leishmania*. His group (I. Galindo, P. Guevara) is dealing with ribosomal gene organization of *Leishmania* by Southern blotting and molecular cloning. They used recombinant plasmid containing a large portion of the ribosomal gene spacer as a probe to compare DNA digests from different *Leishmania* species. The constructed probe has a significant potential value for clinical diagnostic purposes but further studies are necessary before it can have any practical applications.

Pulsed field electrophoretic techniques are used and one version, clamped hexagonal circuit (CHEF), which generated homogenous electric field, as been developed in the study of the electrokaryotype of *Leishmania maxicana*. Very interesting articles have been recently published in good journals. I was really impress by the potential and the quality of this group.

- Microbiology

Mr. T. Isturiz, K. Davidowich, J. Vitelli-Flores are studying enzymatic activities involved in the initial gluconate catabolism in *Escherichia coli*. They have determined kinetic characteristics of gluconokinases in mutants and have support for the model of two gluconate utilization systems in *E. coli*.

Recently, they obtained *E. coli* strains with multicopies of the gene encoding gluconate-6-phosphate dehydrogenase. from such cells they have obtained very strong activity and they claimed to get highly purified enzyme through a simple purification process. The purified enzyme, analyzed by gel electrophoresis, is much more pure than the same enzyme produced by Sigma Company. One realistic objective of this group is to produce other enzymes very commonly used in medical laboratories of the country. They probably have the potential to be successful.

- Botany (Plant Physiology)

The group dealing with *in vitro* culture and plant physiology is coordinate by Eva de García. Several plants are used as models for classical *in vitro* studies. Among the main important are : coffee (*Coffea arabica*) sweet potato (*Ipomoea batatas*), tobacco (*Nicotiana tabacum*), *Canavalia ensiformis*, and some ornamental ferns such as *Pteris cretica* and *Cyrtomium falcatum*.

The basic techniques of micropropagation are efficiently used and the scientific production (articles) seems satisfactory even if most of the articles are produced in spanish.

The main results of this group are :

- regeneration of coffee plants (*Coffea arabica* L. "Catinor") through *in vitro* culture of microcuttings. The developed method can produce 6000 to 11000 shoots in one year in comparison with 100 to 200 shoots that can be obtained by horticultural methods (in collaboration with M. Rafael).

- formation of somatic embryos and regeneration of plantlets from different explants of sweet potato (*Ipomoea batatas* Poir). The plantlets were successfully acclimated to environmental condition.

- growth and differentiation of callus from cotyledonary tissue of *Canavalia ensiformis*. The differentiation of tracheides elements has been studied. Callus were also cultured in presence of different concentrations of canavanine (an important form of nitrogen storage in the seed). Inhibition of growth by canavanine was obtained at very low concentration ( $4.5 \times 10^{-5}$  M). This inhibition was reverted by adding arginine at the same concentration (in collaboration with F. Aoila).

- clonal mass propagation of the fern *Cyrtomium falcatum* and regeneration of plantlets from leaves explants of the fern *Pteris cretica* (in collaboration with L. Furelli). This technique is now classically used by many commercial laboratories to produce large quantities of ferns.

This group should be incorporated in a program dealing with tropical or ornamental plant transformation.

### 3.- IVIC = Instituto Venezolano de Investigaciones Cientificas

This important Institut is located about 20 km outside Caracas. Two groups have been visited : one dealing with Legumes-bacteria-virus interactions (headed by Maria Luisa Mayoral) and one group interested in rotaviruses (Ferdinando Liprandi). Both groups are located in the Microbiology Center which has good facilities and a satisfactory equipemnt. They also have collaboration and grants with other laboratories outside Venezuela. M.L. Mayoral has a scientific contract with EEC which include a spanish laboratory and F. Liprandi has a grant with INSERM (France).

#### \* *M.L. Mayoral's group. (M. Sicardi de Mallorca, R.C. de Uzcategui...)*

This group is dealing with the effect of virus infection on Legumes. Virus infections of host plants adversely affect both nodule development and nitrogen fixation. In cowpea (*Vigna unguiculata*) plants nodulated with two strains of *Rhizobium* cowpea, the effect of infection by the cowpea mosaic virus (Cp MV) on several parameters relevant to symbiotic nitrogen fixation was determined. The effect of CpMV infection on leaf chlorophyll content, leaf area carbohydrate level, leaf proteins and growth of nitrogen-supplied plants, as well as the symptoms induced in the leaves, were less conspicuous than in nodulated plants. The results indicated the need for effective control of the virus and selection of appropriate rhizobial strains which show better performance in virus-infected plants.

This group is also in charge of a small production unit for inoculants. They produce mainly *Bradyrhizobium* inoculant for soybean, but only for the need of the country. 60000 packs of inoculants are already produced and this production might be transferred to a private company in Venezuela. Up to now 20 000 ha of soybean are grown in Venezuela and 120 000 ha in Colombia. These surfaces are increasing and production of inoculants shoud triplicate in the future.

#### \* *F. Liprandi's group (J.E. Ludert, F. Michelangeli, J. Esparza...)*

Little information is available on the early stages of rotavirus replication. This group is studying early steps of replication (penetration and uncoating) of porcine rotavirus in MA-104 cells. The entry of the virus occurred by receptor-mediated endocytosis and that uncoating (removal of the outer capsid) could occur by the effect of lysosomal enzymes. Lysosomotropic drugs (chloroquine) were found not to inhibit rotavirus replication. Recent results suggests that low  $Ca^{++}$  concentration in the intracellular microenvironment may be responsible for rotavirus uncoating. Electron microscopic techniques, and biochemical and immunological studies

(proteins analysis by PAGE, antigens utilization) are classically used.

At IVIC, two other group were mentionned but each responsible person was absent :

- Manuel Rieber (Molecular biology)
- José Domingo Medina (Antibiotics and secondary compounds).

#### 4.- CENIAP = Centre National Investigaciones Agro Pecouara

This applied center is located in Maracay, approximately 100 km outside Caracas. It's a wide center with large facilities for *in vitro* tissue culture. Laboratories have elementary equipment but huge growth chambers (6), hundreds of square meters in 3 green houses and hectares of experimental fields.

During my visit I had discussions with two scientits in charge of *in vitro* cultures and field trials : Ventura Gonzalez and Humberts Reyes.

This center is involved in classical tissue culture within the next 5 years, they have planned to do some genetic engineering works. Several scientits who might be involved in this approach are currently trained in some american laboratories (Ohio) and in Mexico. More well trained people is certainly a necessity. In addition, specific equipment and scientific informations (library) are also needed, almost nothing is available.

Up to now, micropropagation and cleaning plants from pathogens are the main objectives for cacao, sugar cane, papaye, apple, avocads, citrus, mangoes and potatoes. Regarding cacao which has many pathogenes, a germplasm bank has been created with creole cacao. Somatic embryos and haploids obtained from culture of anther have been cleaned from pathogens. Resistant clones are under selection. Sugar cane is also an important program ; clones resistant to bacteria and virus are selected after chemical or gamma mutagenesis or using somaclonal variation. Selection of salt resistant clones is also realized through cell suspension culture, callus production and differentiation. Microtubers production and maintenance of clones is accomplished for potatoes. Oil palm is an increasing production in Venezuela ; micropropagation is also in use for this crop. Apple plants have been recently cultivated in the country and grappes might be introduced in the future. Maintenance of cassava material is also a minor project. Among the legumes, *Phaseolus* and *Vigna* are the main production, and in Cereals, rice, sorgho and corn are the principal crops studied in the CENIAP.

Finally, this center has a great potential for applied studies and maintenance of materials but should work in collaboration with centers involved in more basic research. I also suggest to focuse on specific, very define, projects.



#### IV.- INSTITUTIONS OUTSIDE VENEZUELA

Several Institutions outside Venezuela have already developed collaborative projects with this country in plant biotechnology :

- The CIP (International Potato Center) in Lima (Peru) has expertise for potato and sweet potato studies. On a routine basis, the center carries out transfer of technology activities as relates to the preservation of germplasm, besides the distribution of vegetative material of the products indicated. Researchers in CIP in cooperation with scientists from the United States (Louisiana) are presently using the *Agrobacterium* technology for inserting genes into potato clones and possibly other solanaceous.

- The CIAT (International Center for Tropical Agriculture) in Cali (Colombia). In this country, technology for tissue culture has undergone important developments in recent years. At present about 15 laboratories in the public or private sector are producing plants for micropropagation. According to information received, Flor America operates with about 40 laminar flow chambers, thus making it the company of highest production in Colombia and one of the largest in Latin America. The CIAT has achieved important advancements in the field of tissue culture. They have this technology for :

- the production of planting material for healthy cassava,
- the reduction in the period for obtaining rice varieties through induction and usage of haploids for its improvement,
- the *in vitro* preservation and exchange of world wide cassava collection
- the obtention of mutants for leguminous pastures through the regeneration of protoplasts.

- The CATIE in Costa Rica might also be involved in cooperative projects financed by CAF. This Center is mainly working with tomatoes, ornamental plants, banana and palm plants.

- The CIMMYT in Mexico could eventually participated into a joint project on corn.

#### V.- CONCLUSIONS

The development of plant biotechnology, as true for other aspects of biotechnology, demands the availability of sophisticated infrastructures in research and production, highly specialized personnel in multiple disciplines, and investments of a risky nature to face long and costly research for the development and testing of new biotechnological products to be later

introduced into the market. At present, only a limited number of industrialized countries have been in a condition to undertake these biotechnologies. However, in Latin America, there are some known and available biotechnologies which are important for the Subregion because of the positive effects their development would have in the production and research sectors and also because of the possibilities of their implementation and adaptation is short-term. Among them are the following :

- *in vitro* culture of meristems and tissues
- preservation of germplasm
- improvement of agricultural produce (cleaning of vegetative material from virus ...)
- genetic engineering and transformation of plants, especially potatoes (and other solanaceous) and Cassava.

The comparative advantages presented by the Andean Subregion for improving the agricultural sector through the promotion of biotechnological applications are as follows :

- The subregion has a natural and substantial genetic source for several products which are important worldwide : native fruits, potatoes and other andean tubercules, pasture, palm, rubber, ornamental plants, quinoa seeds, chenopodiaceae, cocoa, foresty species ...

The tropical conditions, and in many areas of the subregion the characteristics of solar radiation, have a bearing in their quality and in shortening breeding cycles, thus allowing for harvesting all year around.

- The unemployed or underemployed labor.

The National Biotechnology Program has been defined to coordinate research projects and the CAF is promoting the articulation of projects in research centers, both at national and subregional levels. Based on the verification of the availability of specialized personnel, equipment, and mainly taking into consideration the needs and interests of each country, the CAF is verifying the possibility of organizing the projects. Up to now, several centers I have visited in Venezuela are already supported by CAF through the Biotechnology Program (IDEA, project 18 ; UCV, projects 20 and 22). These centers seem to work in a relatively isolated manner, thus CAF has to coordinate research activities, for exemple between IDEA, UCV and IVIC.

In all visited centers, physical structures are adequately available. For most of them, equipment and technology are adapted on a short term basis. However, mainly in IDEA and CENIAP, a critical mass of highly qualified researchers and specialized technicians hasn't been reached. An extra effort should be done for intensive postgraduate training courses prepared by experts working in the public and private sectors. In addition, resources are

needed for long- term educational program : preparation of M. Sc. or Ph D. The training would be carried out in laboratories granted by CAF in the Subregion or in other laboratories outside Latin America. Another task would be to facilitate contacts between research centers with agricultural centers, industrial associations, farmers groups, export associations and similar entities.

Finally, it is clear that the research centers visited have already good facilities and are conducting very interesting research programs. Coordination by CAF seems to be important if support would be granted.