

# CIRAD 1994



CIRAD



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The Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) is a French research organization that specializes in agriculture in the tropics and subtropics. It is a state-owned body and it was established in 1984 following the consolidation of French agricultural, veterinary, forestry, and food technology research organizations for the tropics and subtropics.

CIRAD's mission is to contribute to the economic development of these regions through research, experiments, training, and dissemination of scientific and technical information.

The Centre employs 1800 persons, including 900 senior staff, who work in about 50 countries. Its budget amounts to approximately 1 billion French francs, more than half of which is derived from public funds.

CIRAD is made up of seven departments: CIRAD-CA (annual crops), CIRAD-CP (tree crops), CIRAD-FLHOR (fruit and horticultural crops), CIRAD-EMVT (livestock production and veterinary medicine), CIRAD-Forêt (forestry), CIRAD-SAR (food technology and rural systems), and CIRAD-GERDAT (management, common services and laboratories, documentation). CIRAD operates through its own research centres, national agricultural research systems, or development projects.



# CIRAD

## 1994

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## ***The President's Message***

*In 1994, CIRAD took several initiatives to reinforce its involvement in European structures for research and development. As such, CIRAD is participating more fully in the construction of Europe's scientific community and will strengthen European research in order to support countries of the South in their development.*

*CIRAD is a member of Natura, a European network of universities and agricultural scientific complexes working with tropical and subtropical countries. It is also a member of ECART, the European Consortium for Agricultural Research in the Tropics, in association with British, Dutch and Portuguese institutions. Two German organizations joined ECART this year and others are expected to follow. We exchange researchers, rationalize our diverse activities and draw up projects in common with these European partners and with others throughout the world. CIRAD welcomes partner research teams to use its facilities in French overseas departments and territories, while in the South it contributes to the promotion of European policies in support of regional programmes.*

*CIRAD is backed in its efforts by the European Commission. The Fourth Framework Programme for research, technological development and training has just been adopted. It has been endowed with a budget that ranks third among all programmes of the Commission. It is in this same spirit that European research and development ministers are defining a strategy of cooperation with countries of the South. Research in agronomy and medicine will play a key role in the progress which is expected in the coming years.*

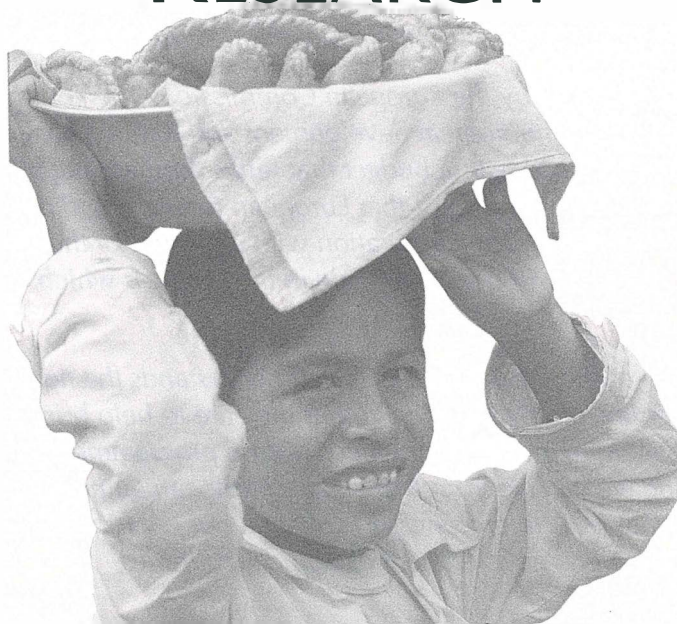
*CIRAD is at the heart of these activities. Our staff understands the necessity for closer cooperation between the North and the South if they are to help bring about the second green revolution. I am convinced that the cooperation programmes we set up and the financial backing we receive from French and European authorities augur well for success. They will enable us to prolong and enhance our contribution to world research for the economic and social development of tropical countries.*



Guy Paillotin  
CIRAD President

A Shared Adventure

# TOWARDS WORLD COOPERATION IN DEVELOPMENT RESEARCH



For perhaps the first time in their history, most of the institutions involved in agricultural research for development agree about the prospects for the future, about the strategies to adopt and about their willingness to work together.

## CONVERGENCES

WHEN IN 1990 CIRAD began the CIRAD Strategic Plan *Strengthening our Cooperation in a Changing World*, it called for deliberations on nutrition and the environment with one of its maxims: "Increasing production while protecting the environment". Given new impetus through work carried out by IFPRI, this topic was at the heart of the discussions in 1993 and 1994 led by CIRAD's group on evolution and strategies, a task force on CIRAD's long-term orientations. The major underlying preoccupation that dominates the current period is that population growth and increasing food needs, coupled with the use of high-yielding systems stemming from rapidly evolving technologies, could endanger the balance needed for sustainable crop management. Under these conditions, will it be possible to ensure food security in the long term? Posed in these terms, it becomes apparent that environment and food production are inextricably linked.

In the hope of resolving the crisis, the Consultative Group on International Agricultural Research (CGIAR) asked CIRAD experts to join others in determining what challenges the developing countries would have to face by 2025 and to give new direction to international agricultural research. The group's report, *Sustainable Agriculture for a Food-Secure World*, was published in 1994. It mirrors many of CIRAD's ideas and introduces a new concept, the doubly green revolution, and suggests that the international system should be reformed on an ecoregional basis, another new concept. Along the same lines, IFPRI launched "A vision for the year 2020", a vast programme designed to create a consensus on questions of food, agriculture and the environment and to which CIRAD also contributed.

The CGIAR, in the process of a major reform, called for a meeting of its donors at ministerial level in February 1995. The French Ministère de l'enseignement supérieur et de la recherche addressed the meeting on scientific needs in the fields of nutrition and environment in developing countries and suggested, on behalf of

the European scientific community, that a strategy be set up involving all Northern and Southern partners on an international scale.

Parallel assessments by the international community point toward the same diagnosis, which will demand collaboration in daringly innovative solutions.

### **The diagnosis**

The first element of the diagnosis is that 700 million people do not have enough to eat today, at the end of the 20th century, and that this number will increase more or less rapidly over the next decades, depending on the regions of the world considered. The most worrying forecasts are for Asia—even though this region's population growth is said to be at a "transition stage"—and for Africa, where the present generally low population density is rising sharply.

As the planet approaches demographic saturation—there will most likely be 8.5 billion people by the year 2025, 7 billion of whom will be living in developing countries—the need to produce ever more food will cause ever greater environmental dangers, especially to soil fertility, water and forest resources.

### **From one revolution to another**

The second green revolution is a response to the anticipated long-term deterioration in the world's food situation and natural resources which might result from these trends.

The first green revolution was based on the use of intensive production technologies—new high-yielding rice and wheat varieties, fertilizers and pesticides—and its application within the framework of activist economic policies enabled Asian countries to meet their rising demand for food.



But at present the dynamics of that technology-based revolution are decelerating. For reasons which remain unclear, yields are stagnating, despite still largely untapped biological potentials.

The green revolution was successful in other parts of the world, but some regions did not succeed with it. This is the case in Africa where natural environments are often hostile to production, farming systems differ widely, infrastructure is inadequate, new institutions are unstable and society's demands for technological change are quite different. Only the "white" revolution, that of cotton, succeeded in generating income and stimulating food crops.

Both Asia and Africa need to produce more. But, to the successful ingredients of the first green revolution, the new agricultural revolution will have to add another dimension—the necessity of protecting natural resources so that cropped ecosystems can be renewed permanently. The notion of "sustainability", or viability, is none other than the age-old concept of fertile land being the capital one hands down to one's children.

The new revolution will be "doubly green" because of this marriage between high productivity and ecological sustainability. It can no longer be based purely on technology if it is to address poverty and food insecurity. It must stem from the needs of poor populations, create jobs for those who have little or no land, help small farmers as well as larger ones, not only in regions of high productivity potential but everywhere people farm for a living. Decision-makers for agriculture at all levels must be involved to ensure that the support required is forthcoming.

## **The ecoregional approach**

The second green revolution embodies the concept of an ecoregional approach emanating from the CGIAR's review of how to reform the work of the international centres. It was defined as a mechanism for partnership applying research to the scope of technical and human problems implicated in the sustainable increase of agricultural production in any given area.

## **CIRAD in French overseas departments and territories**

In 1994, after consulting its local partners concerning their priorities, CIRAD outlined its policy with respect to the overseas departments and territories (DOM-TOM) for the next decade. This policy revolves around three main axes.

Rural development via strategic research remains the first priority. Research for development must respond to social demand and be organized in partnership with the governing authorities and with members of the agricultural professions.

The second priority is the setting up of centres of excellence to further research CIRAD considers to be strategic to its interventions in the DOM-TOM. This decision is based on the ongoing requirements of research in these areas. Each centre of excellence will work in the specific context of the region's potentials and the local farmers will be the first beneficiaries of their innovations: in Guadeloupe, genetic improvement of the banana and tropical animal pathology; in Martinique, fruit trees and garden plants; in French Guiana, an observation post in the Amazonian forest; in Réunion, sugarcane and plant protection; in New Caledonia, genetic improvement of animals; in French Polynesia, genetic resources. These centres of excellence will have a vocation to host other researchers, especially those belonging to the European Union who wish to pursue work in tropical research.

Third, CIRAD will contribute to the training of local staff and will encourage regional scientific and economic cooperation.

CIRAD is also taking part in the negotiations under way concerning the new planning agreement between the government and the regions for the period 1994–98. CIRAD was reinstated in French Polynesia in 1994 within the framework of the Pacte du Progrès.

Lastly, CIRAD is working together with the DOM-TOM, Spain and Portugal (Canary Islands, Madeira, Azores) to create a group with tropical expertise at the European level which may be represented in the European Commission's common research centre.

French research (CIRAD, INRA, ORSTOM) endorses the concept and offers its scientific experience in meeting these challenges.

Experience has shown that if research results are to be adopted as new technologies for productivity growth or natural resource management, they must respond to the needs and strategies of the very people who will use them as tools of production or management. The diversity of regional situations must therefore be taken into account.

To identify regional interests and research needs it is necessary to synthesize the knowledge already available and to diagnose the way the region functions from different standpoints: its landscape and natural resources, the organization of its agricultural subsectors, and the economic policies (prices, credit, trade, land-use rights and management, etc.). All those concerned contribute to the diagnosis, then help outline the research programme and construct its institutional framework. From the start, it is necessary to pursue a process of negotiation between society's demand for research and its supply.

As research findings become available, they are put into practice. This interaction between researchers and users ensures that research is adapted rationally to real situations and clarifies the need, if any, for supplementary research.

The ecoregional approach is an iterative process—grounded in a systemic approach to examining an environment on different scales—which French institutions will encourage their partners to adopt for further sustainable regional growth.

## NEW FIELDS TO EXPLORE

**T**OGETHER, the thrusts of the doubly green revolution and the ecoregional approach open up new and fertile fields of exploration. CIRAD's consultations with each of its disciplinary areas

revealed that some have been using these methods for a long time, others for only a few years and in certain aspects of their work. As CIRAD examines its achievements, its aims and methods in this new light, closer analysis reveals often surprising but productive synergy and programme innovation.

## **Think differently about development**

Any topic can be examined with a wide-angle lens. Two examples from quite different fields can be used to illustrate this: the theme of town-country relations and a research-development project of broad scope which is in the process of becoming an ecoregional project.

CIRAD convened various specialists to examine town-country relations at a seminar entitled "Nourrir les villes" (Feeding the towns). The economic environment and to a large extent the development of rural areas is structured and conditioned by the towns. Farmers decide to produce more than they need only when they are assured of a market for their produce. Access to such an outlet is often not obvious. What is usually studied are the two ends of the chain, production and consumption (supply and demand). But along the chain, exchange between producer and consumer is organized around five functions: production, transport and storage, processing, redistribution, consumption. These five functions can be approached from the angles of geographic dispersion, economic efficiency and social relations. Certain constants emerge from analyses carried out by various CIRAD departments in many countries of the rural to urban supply chains of rice, tubers, fruits and vegetables, animal products and firewood. A product's market sales are determined by its characteristics: its quality is related to consumer expectation based on habit, but new or improved products may be adopted. Research in the field of rural food processing assumes greater importance when set in the light of supplying towns regularly from nearby, since processing and transport are the two notable bottlenecks to achieving this aim. Intra- or periurban produce (mainly certain vegetables and animal

products) complement rather than compete with rural production. But imports, which do not always correspond to a lack of market supply, often present a real threat to local producers because of their marketing thrust and the nature of the products. The town as a market place appears to be the key element in improving farm incomes, creating jobs in rural areas and modernizing farming. For this reason, supplying the town should be thought of in terms of strategies at a scale which includes not only the national level, but also the scope for complementarity among neighbouring countries.

The Garoua agricultural development project for northern Cameroon has produced a plethora of results, some of which have already borne fruit economically. There are now sound reasons for shifting into a higher gear and associating research teams from three countries—Cameroon, Central African Republic and Chad—in a truly ecoregional project. First of all, the central African savanna covers a region which is ecologically homogeneous; the climate, which is characterized by a single rainy season that lasts longer as it moves from North to South, is conducive to a range of products: rainfed cereals, cotton and livestock throughout the zone, roots and tubers in the south, vegetables and fruits in the valley bottoms and in irrigated areas. Next, the three countries have benefited from the presence of cotton development programmes. Lastly, the region is in a migratory flux, with heavily populated zones contrasted with low-density zones, and the problems this entails. A regional approach should organize research in relation to society's needs and the main development axes, i.e. food security and well-established local markets for food crops; competitiveness of cotton and rice, including quality improvements; encouraging improvements in agronomy and sustainable agriculture. The three countries have highly complementary research structures. Their cooperation, in partnership with all those concerned with development, should engender an effective synergy.

A similar approach forms the basis of several other regional programmes which are at different stages of development: the CERAAS, Centre d'étude régional pour l'amélioration de



l'adaptation à la sécheresse en Afrique de l'Ouest (regional drought resistance study centre); le programme d'étude, d'amélioration et de gestion de la jachère en Afrique tropicale (programme for the study, improvement and management of fallow lands in tropical Africa); le pôle régional de recherche sur les systèmes irrigués soudano-sahéliens (the regional centre for research on Sudano-Saharan irrigated systems); le consortium de recherche sur les bas-fonds de l'Afrique de l'Ouest et du Centre (Inland Valleys Consortium).

## Reassess technologies

The second green revolution calls for an adaptation of technologies. Specialists who already work in the most open multidisciplinary context are analysing their work in the light of these new concepts. Even if some researchers—notably those working on plant improvement—speak in terms of evolution rather than revolution, because their contribution derives from a long and continuous process, they all foresee important advances in the research in progress. Plant improvement, crop protection and agronomy are three examples.

The field of plant improvement already globally meets the criteria of a second green revolution. Breeders decided, against the main trends of thought in the North, to increase tropical crop yields. By so doing, they are contributing to food security and to the creation of income for small farmers. By producing new varieties adapted to difficult or marginal growing conditions, they are making it possible to reclaim degraded land and extend cropping to as yet uncultivated areas. The viability of their achievements is manifest: in varietal stability, across time and space; in enduring resistance to disease, insects and abiotic stress, such as toxicity of the natural environment, drought, or cold where high-altitude crops are concerned; in the preservation of genetic resource diversity, to which CIRAD contributes with its internationally renowned collection of rice, maize, sorghum, millet, groundnut, pineapple, cotton, banana, plantain and natural rubber.

Considerable progress has been achieved using recent technology—plant genome mapping, marker-assisted selection, in-vitro multiplication, genetic transformation—and breeders are convinced there will be more.

In the present context, environmental protection calls for a drastic decrease in the use of pesticides. The methods that are being advocated today stem from concepts and research proposed long ago. But they are only now beginning to show on-site results, which it is hoped will lead to their rapid adoption. For example, the biological control of insect pests by their natural parasites is increasingly successful for fresh vegetable crops, cotton and coffee. However, chemicals still need to be used where neither resistant varieties nor biological controls exist. But recommended methods now use fewer chemicals and target the pests in question in order to save money and preserve the environment, while nevertheless providing efficient protection. Conventional treatments of cotton, one of the most pest-infested crops, have given way to different types of control, according to the croppers' training and their organizations' level of technology. In the same vein, early-warning methods are being devised so that producers on a regional scale will begin treatment before the damage threshold of the pest or disease has been reached (as in the case of black Sigatoka disease in banana and plantain). Many of these technologies can be combined in what is known as integrated pest management.

An example of how to adapt cropping systems and technologies to the absolute necessity of saving the resource capital represented by the soil, which has been badly damaged by erosion, is to be seen in the vast pioneer farming zones in west Brazil. The systems devised in this context—based on sowing in untilled land, permanent ground cover, successive double cropping of annuals, integrated herding—are recommended for use in low-altitude humid and equatorial tropical regions in Africa and Asia.

## Welcome diversity

The first green revolution was successful in the context of one particular type of ecosystem, characterized by a main crop—rice—a densely populated farming community applying meticulous techniques, with abundant water and an effective irrigation network. The second revolution, if it is to take place, will have to welcome diversity to the front of the stage.

Instead of seeking to limit diversity, recognizing it and putting it to use will speed up the development of ecosystems that differ according to physical and human conditions.

The concept of regional diagnosis must be based on diversity, as must the approach to farming systems and smallholdings.

The Garoua project in Cameroon has underlined its importance. The regional homogeneity already mentioned must not mask the wide diversity of the natural and human environment, which is to be found at all levels—in small farming regions, villages, localities and, finally, in cultivated plots.

Elsewhere, in Mali for example, the importance of diversity in smallholdings and cropping practices was revealed by a study of intensified rice cropping on the irrigated land bordering the Office du Niger, which is being rehabilitated. Due to the regulated framework which was imposed in the past, farmers were treated as though they were all grappling with identical problems, whereas in reality 12 different types of farming situations were in evidence. Diversity is apparent primarily in the farmers' aims and the means at their disposal and its recognition is considerably facilitating the advisers' interaction with the farmers.

## Evaluate sustainability

Although sustainability is considered a fundamental principle, it has yet to be defined and evaluated theoretically; a model comparing the effects of various possible policies is needed. It was with this in



mind that a preliminary bioeconomic model was constructed. This model can assess qualitatively and quantitatively the consequences of economic policies on the perennality of natural resources.

The model has already been applied to the maize-producing region of the Argentine Pampa, where soil is being eroded and impoverished due to the disappearance of cattle herds, poorly adapted tillage methods and sharecropping. Decision-makers can foresee the effects, for example, of an environment-oriented credit policy or the repercussions of different price policies on land occupancy, livestock leasing, smallholder profits and soil protection.

In a western Burkina village where production is mainly for home consumption, a reduction in plant cover and, consequently, erosion result from the overuse of common resources (fallows and scrublands). The model shows the effects on erosion and farm household parameters of hypothetical interventions, such as limiting livestock access to pastures, loan allocations or price policies.

### **Compile ecoregional data**

The dynamics of the ecoregional approach are determined largely in geographical terms. Immediate access to information is available through geographic information systems (GIS) comprising powerful software applicable to the second green revolution and the ecoregional approach, which provides a spatial evaluation of constraints, possibilities and changes on different scales. It is irreplaceable for drafting and managing projects and for national and regional planning.

Several GIS frameworks are already operational or being compiled on a small regional or local scale: on natural resources in Cape Verde Islands; on farmer organizations and land use in the Senegal River valley; on the interaction between natural resources, herding and farming activities in southwestern Burkina.

Research is being carried out for the seven member countries of CILSS on combining a conventional GIS database with various technology and economic models. Analysis of the effects of factors shown by the models of cropping/forestry/herding systems can then be extended to natural resources. When it is perfected, this interactive tool will contribute to the reasoned choice of medium- or long-term agricultural policies in relation to a country's spatial dynamics.

A multimedia information system is also being compiled for the Amazon basin. The available data which are now dispersed and on different scales will be collated with the two-fold aim of improving people's living standards in the eight countries concerned and of supporting a programme of biodiversity preservation.

### **Create decision-making aids**

Economic policies will weigh heavily in whether or not a new green revolution or the ecoregional approach will succeed. Governments may be withdrawing from direct intervention in agriculture, but they will remain responsible insofar as their economic policies have decisive effects on the agricultural sector. How will they choose which policies to adopt when there are so many factors—including international considerations—to contend with? How will they assess the risks incurred by different economic agents? How can they instigate, stimulate, and sustain agricultural growth?

Models do exist to help decision-makers analyse the macroeconomic context, agricultural production and marketing channels and situations at the level of the farm household. They are designed to clarify and represent the manners in which the various people concerned cope with environmental restrictions and opportunities, to assess the range of possible reactions to an economic policy decision and the measures' effects on specific groups, such as poor farmers or rural craftsmen. Since risk has always been a determining factor in how farmers make decisions, reducing risk would appear to

be essential for policy-makers. Several situations have been analysed, notably in Indonesia, Benin, Burkina and Cameroon.

These models integrate elements from sustainability models and geographic information systems in a simplified form.

In a broader way, France's involvement with developing countries in their research on agricultural policies has taken on a new dimension, as witnessed by the number of publications in this field, to which CIRAD has contributed.

## NEW PARTNERSHIP ROLES IN DEVELOPMENT

**T**HE NEW PRINCIPLES that govern agricultural development and the research that must accompany it entail the burgeoning of new processes of consultation and decision-making. A phenomenon now emerging is that of those involved organizing themselves to become partners, with public bodies and research teams, in their own development.

### Redistributing responsibilities

Are present institutions best qualified to manage renewable resources within the framework of the second green revolution? This question is raised with increasing frequency and CIRAD is carrying out relevant research and is applying its findings where possible.

A case in point is that of certain forests or conservation areas (Guinea, Madagascar, etc.) which are theoretically protected but nevertheless inhabited illegally. To arrive at a long-term *modus vivendi* which respects both the social and natural dynamics of such a situation, the best approach would seem to be to confer the management of these lands on the people concerned, under

clearly defined conditions, with the forestry services assuming a new technology advisory role.

Here, sustainability is seen in terms of land-use negotiated at a local level, with the government as arbiter. In such cases it is not unusual for institutions to undergo structural changes or decentralize.

The new agricultural policies in Africa and Latin America will engender the birth or reinforcement of farmer organizations of many kinds in response to the government's withdrawal. There is little doubt that these organizations will foster modernization and productivity. Their aspirations are two-fold: to be recognized as full partners in the processes of defining and setting up development programmes and in managing agricultural policies; to contribute to technology change—and for this, to be better informed, better trained and in closer contact with research. It should be possible, by redistributing responsibilities within local bodies called upon to play a more active role, to create the conditions necessary for a new approach to natural resource management, local development planning, infrastructure supervision. However, the government should set up economic, legislative and regulatory frameworks to encourage a moderate pace of transition.

CIRAD recognizes the emergence of farmer organizations as an essential element in recent changes and is analysing the ways in which they function and the means of supporting them. This research is being carried out in cooperation with other institutions concerned with rural development, but also with the organizations themselves.

### **Participating in research**

On the level of agricultural research as such, these organizations have a major role to play in expressing their specific technical needs, which will naturally lead to their participation in defining development-research programmes.

Before it was widely recognized that organized farmers' groups were an important strategic element, CIRAD had already carried out research in close cooperation with farmers. In many countries as different as Brazil, Côte d'Ivoire and Madagascar, farmers were already participating in CIRAD research, testing on their lands the technology that scientists had conceived. Working together in this manner results in a concerted choice of the best solutions and immediate feedback of information that can change the course of research. It is the bedrock of true development research.

Initiatives like these assume new dimensions with farmer organizations, since, as opposed to only a few enlightened individuals, the entire village community organization becomes a partner in research, i.e. a true partner, insofar as they participate from the beginning in defining the objectives. Farmer know-how and research expertise are combined to respond to the diverse situations encountered. One of the best examples of this approach can be seen at present in the grain research programme being led by the Central American countries, where around 30 farmer groups are taking part.

Major research organizations and governments are agreeing on a new dynamic approach to agricultural development, and farmers are assuming responsibilities and their rightful place—so the first conditions for a second green revolution are being met.



A photograph of a man in a field of rice plants. He is wearing a traditional head covering and a shawl. He is looking down at a bundle of harvested rice. The text "Annual Crops Department" is overlaid on the image.

# Annual Crops Department





**I**n 1994, the *Département des cultures annuelles*, or CIRAD-CA, consolidated its cooperative research programmes according to the two main objectives set out under the terms of its 5-year research strategy: improving the annual crop production sub-sector, and approaching rural development, cropping systems and farming systems from an ecoregional perspective.

*The annual crop production and marketing sub-sector is facing increasingly important and often urgent challenges—dealing with food deficits,*

which could reach 700 million t/annum of cereals by 2025, addressing the rising demand of the cotton industry for fibre and meeting oil and sugar crop needs prompted by overwhelming consumption rates.

The Department has thus decided to concentrate on major topics that could enhance production and competitiveness in essential areas of the sector. These include plant material, cropping and input provision, crop harvesting and product improvement, with increasing stress on economic and processing aspects of annual crop production. Research programmes are focusing on five specific commodity sub-sectors: rice, other cereals, protein-oil crops, cotton and sugarcane. Research on root and tuber crops is being conducted in collaboration with other CIRAD departments, ORSTOM and research and development partners.

The ecoregional approach to rural development results from long-standing conventional agricultural research strategies. In 1994, this research thrust was particularly accentuated through initiatives of the Consultative Group on International Agricultural Research (CGIAR) and the French Ministère de l'enseignement supérieur et de la recherche, on "ecoregionalism". CIRAD-CA intends to be constructively involved in these initiatives and will propose new research strategies based on its firsthand research results. Four new research programmes have been outlined: smallholder farming in savanna areas, smallholder farming in irrigated areas, smallholder farming in highlands and newly cultivated areas, sustainability and environmental resources. This should enable the Department to clearly target operations in regions under specific predetermined strategies for research and sustainable development.



## RICE

The rice programme is currently developing new varieties, including an upland rice variety in China, inserting agronomically valuable genes into improved varieties, characterizing and quantifying industrial and cooking quality criteria for different varieties of rice.

### Transgenic Rice Plant Propagation

More than 250 transgenic rice plants have been regenerated from protoplasts of embryogenic cell suspensions using genotypes of common Mediterranean varieties (Miara, Ariete and Thaibonnet).

Molecular analysis of these plants and some of the progeny confirmed the integration and transmissibility of the inserted gene (a herbicide-

## ANNUAL CROPS DEPARTMENT

### CIRAD-CA

Director  
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Research Director  
Jean-Claude Follin  
Acting Programmes Director  
André de Courville  
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Harry Palmier  
Administrative and Fiscal  
Director  
Léandre Mas

### Commodity Sector Research Programmes

Rice  
Henri Feyt  
Other cereals  
Jean-Leu Marchand  
Protein-oil crops  
Robert Schilling  
Cotton  
Michel Déat  
Sugarcane  
Jacques Marquette

### Ecoregional Research Programmes

Smallholder farming  
in savanna areas  
Guy Faure  
Smallholder farming  
in irrigated areas  
Jean-Claude Legoupil



*Ecoregional  
Research Programmes (cont'd)*

Smallholder farming in  
highlands and newly cultivated areas  
*Alain Leplaideur*  
Sustainability  
and environmental resources  
*Francis Forest*

**Research Units**

Plant improvement  
*Michel Jacquot*  
Crop physiology  
*Pierre Sibaud*  
Farming systems  
*Michel Crétenet*  
Soil and land-use  
management  
*Francis Ganry*  
Water management  
*Florent Maraux*  
Plant pathology, weed  
management  
*Jean-Loup Notteghem*  
Applied entomology  
*Jean Cauquil*  
Biometrics,  
computer services  
*Alain Joly*  
Cotton technology  
*Eric Héquet*  
Cereal technology  
*Jacques Faure*  
Commodity economics  
*Claude Freud*

**Support Services**

Publications, information,  
documentation  
*Hervé Saint Macary*

resistance gene against phosphinothricin) used to select transformed in-vitro cultured cells. The high abnormality rates noted in some plants, e.g. albinism and unusually high ploidy, should be reduced in the future.

It is quite likely that this gene transfer system would be effective with tropical upland rice varieties. In addition, it will facilitate insertion of agronomically beneficial genes into elite varieties and the functional analysis of some promoters that regulate gene expression.

The transfer of herbicide resistance in rice is of considerable interest for weed control, but the red rice phenomenon should be controlled. CIRAD and the Institut français de recherche scientifique pour le développement en coopération (ORSTOM) are therefore conducting a collaborative study on the origins of these wild rices that tend to overrun cultivated rice fields.

Moreover, pest resistant varieties could be developed by transferring, from other plants, endotoxin genes against *Bacillus thuringiensis* and protease inhibitor genes against borers. Promoters that control the expression of insect resistance genes are currently being

assessed in collaboration with the Université de Perpignan and the Consejo Superior de Investigaciones Científicas (CSIC), in Spain.

**A New Rice Variety for  
Mediterranean France**

Inca, a rice strain introduced from the Centro Internacional de Agricultura Tropical (CIAT) in Colombia, has just been accessioned in the French collection. This extremely hardy strain can adapt to a broad range of soils and puddling conditions and produce high and sustained yields. Moreover, it is a slender long-grain rice which should appeal to consumers considering current market trends.

Inca belongs to the *japonica* subspecies. CIAT obtained this line by breeding Diamante with progeny of the Lemont x Quilla 66-304 cross. Lemont is a North American variety with well established cropping and processing qualities, while the others are of Chilean origin.

In addition to its high productivity, Inca adapts remarkably well to various climatic and cropping stresses, i.e. very good emergence performance under anaerobic conditions, excellent recovery after cultivation accidents at the onset of growth, a suitable growth cycle for Mediterranean

French conditions, and good resistance against the main pests and diseases of this region. It is thus able to produce high, stable yields. From a processing viewpoint, Inca milling yields are high and steady, with excellent steaming performance, resulting in a very high quality cooking rice.

### Eating and Cooking Qualities of Rice

Milling and whole white grain yields mark the processing potential of rice. In the light of the diversifying European market, it is also essential to assess cooking quality and take consumer taste preferences into account. The Centre français du riz, as well as breeders and manufacturers from tropical and subtropical countries, have called upon the CIRAD Laboratoire de technologie des céréales to conduct relevant tests.

An original 1993–94 joint CIRAD/INRA study of “natural” *indica* long-grain A and B varieties, steamed or parboiled steamed, resulted in a taste profile of their cooked textures. The Laboratoire de technologie des céréales carried out the technological and table quality analyses, while INRA conducted the taste tests with a panel of 25 tasters.

A statistical analysis revealed that the 19 assessment criteria initially used by the panel could be represented by six descriptors.

## PRODUCTS FOR DEVELOPMENT

### An Upland Rice Variety Officially Released in China

*IRAT 104, an upland rice variety developed by CIRAD has just been certified for release by the Chinese authorities, which means it can now be grown by Chinese farmers.*

*French rice varieties were tested at a site in southern Yunnan, and in a multilocation network throughout the province, as part of ongoing collaborative activities between CIRAD and institutions in Yunnan that started in 1988. In 1991, IRAT 104 was the most productive variety in Simao district, with 40% higher yields than Gensan, the Chinese control variety. In 1992, it was still the top-producing rice variety in Simao and in seven representative districts in the upland rice cropping area of Yunnan. IRAT 104 yields have been steady and always more than 21.5% higher than the most productive Chinese variety. In 1993 and 1994, tests carried out in farmers' fields confirmed the superior performance of IRAT 104, particularly with respect to its blast disease resistance and drought tolerance. IRAT 104 was obtained by crossing IRAT 13 with Morobérékan, a standard rice variety of Côte d'Ivoire where the rice breeding programme was conducted in collaboration with the Institut des savanes (IDESSA).*

*The outcome of all of these years of testing was the acceptance of IRAT 104 by the Yunnan certification commission, recommending that it be grown at elevations lower than 1,300 m—which corresponds to most of the upland rice cropping area of Yunnan province. These promising results prompted a Chinese-French collaborative project that is currently being set up to improve upland rice cropping in China. The objective is to obtain high-quality grain by sustainable cropping techniques.*

Moreover, the quantitative techniques used by the laboratory efficiently characterize all of the taste descriptors: a universal texturometer measures firmness and stickiness of the final cooked product; elasticity is assessed by elastic recovery on a viscoelastograph; and the proportion of incompletely gelatinized grains indicates the “granularity” of the product.

Correlations between the instrument and taste measurements were found to be nonlinear. Hence, about 30 additional rice samples will be analysed in 1995, and the effects of cooking conditions will also be investigated.

In addition, flavour tests were developed to evaluate aromatic rices; flavour distributions in aromatic x nonaromatic rice hybrids were thus studied.

## OTHER CEREALS

This programme is mainly conducting research on maize and sorghum, but is also dealing with root and tuber crops—which could eventually be handled in a separate programme in the future. In 1994, the most striking results included the creation of five maize varieties resistant to maize streak virus, and development of a field test to assess viruses.

### Maize Varieties Resistant to Maize Streak Virus

In maize cropping systems, the only effective response to maize streak virus (MSV), a serious disease known to devastate entire maize crops in Africa and the Mascarene islands, is to cultivate highly MSV-resistant varieties.

CIRAD was able to transfer MSV resistance from IRAT 297, an excellent quality source from Réunion, to other sensitive but high-yielding maize varieties. This involved an initial cross with a resistant donor (IRAT 297), two backcrosses with the recurrent parent, followed by three selfing cycles. These new resistant varieties were ultimately obtained by crossing the most

## PUBLICATION

### African Yams

Les ignames au Cameroun, *published by CIRAD, partially presents the results of the project "Diffusion des plantes cultivées au Cameroun", which the Cameroonian Ministère de l'enseignement supérieur et de la recherche scientifique entrusted to ORSTOM.*

*In Cameroon, 23 yam species have been inventoried, 16 wild and 7 cultivated species. The most commonly grown yams in this country (and throughout western Africa) belong to the Dioscorea cayenensis-rotundata complex. Most forms of this cultivated complex in western Africa have an annual cycle. In Cameroon, forms cultivated in the north of the Adamaoua region are annuals, but those grown in the central and southern regions are more or less perennials. These annual and perennial yams have different morphological and enzymatic traits.*

*Gene pools for marketable yam species are becoming impoverished because of the low diversity due to a lack of traditional varieties. Urgent measures must therefore be taken to evaluate, collect and preserve yam genetic resources in Cameroon, Ghana, Guinea and Nigeria.*

resistant S3 lines. Maize plants were artificially infested at each resistance transfer step through a leaf hopper vector, *Cicadulina mbila*, which was mass-reared and 100% infectious.

Five out of about 15 yellow and white grain varieties that were bred in this way are now completed, i.e. CIRAD 385, 386, 387, 388 and 389. They showed excellent resistance in tests carried out in Réunion and Africa within the framework of the maize network of the Conférence des responsables de la recherche agronomique africains (CORAF), in association with the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Resistant forms of other varieties should be developed between 1996 and 1998.

Additionally, a genic system of total MSV-resistance was fixed in an homozygous line derived from CIRAD 387. This new resistance source, which is superior to IRAT 297, will be used for transfers to open pollination varieties. It will also be transferred to hybrid parents along with (or without) other resistances to maize mosaic virus or maize stripe virus.

### Field Test to Assess Maize Viruses

The maize streak virus, maize mosaic virus and maize stripe virus can now be serologically assessed in the field. This test is a modified version of standard laboratory immunoenzyme assays and should be useful in determining the geographical distribution of various viruses.

The technique involves depositing extracts of the plants to be analysed onto nitrocellulose membranes. Depending on the time available, the viruses can either be assessed on-site by developing the membranes and comparing them with positive and negative reference membranes, or they can be dried and stored until development at a later time in the laboratory.

## PROTEIN-OIL CROPS

Drought is the main limiting factor for groundnut cropping in savanna areas. This programme aims at avoiding drought stress by developing techniques for adapting irrigation to crop needs and breeding short-season varieties.

### An Innovative Irrigation Technique

It is now possible to regulate irrigation according to the moisture status of the crop. This novel technique, governed by a plant physiological indicator, is the outcome of a European Commission-funded research project on irrigated groundnut cropping, conducted in the Senegal river valley in collaboration with the Institut sénégalais de recherches agricoles (ISRA).

The principle is based on the relation between the plant cover temperature and plant transpiration, thus on the plant's ability to absorb available water. The plant closes its stomata to reduce water release when there is little soil moisture available, which increases leaf temperatures. Temperature differences between the air and the plant cover to be irrigated are measured with a portable direct-reading instrument. A stress indicator is thus calculated in linear relation to the leaf moisture potential.

The stress indicator is 0.3 when the stomata close. This is used as the warning threshold to start irrigation since photosynthesis is markedly affected at higher stress levels.

Testing the system in three irrigated village fields revealed substantial savings as compared with irrigation

regulated according to maximum evapotranspiration. Further experiments on a larger scale are under way to confirm these results.

### Short-Season Groundnut Varieties for Dry Areas

Groundnut varieties that had been bred for drought tolerance were evaluated through three consecutive crop seasons. The tests were carried out in various parts of western Africa and Latin America with low precipitation levels. Early varieties, selected in collaboration with ISRA of Senegal, the Institut d'Etudes et de Recherches Agricoles (INERA) of Burkina and the University of Ceará of Brazil, produced equivalent or higher yields with respect to the control varieties.

In Burkina, the hybrids ICGS 26, ICGS 31 and AHK 85-19 are as productive as the local genotype, but they can be harvested 10–15 days earlier. In Senegal, GC 8-35 and GC 8-13 have two advantages over the control variety, i.e. 30% higher yields and a growing season that is 10 days shorter. In Brazil, the early genotypes GC 8635, ICGS 55 and ICGS 31 were found to have 5–14% higher yields with better quality groundnut seeds as compared with the local variety.



## PRODUCTS FOR DEVELOPMENT

### Phytosanitary Control for Sugarcane Cuttings

*New sugarcane varieties have to be introduced and assessed to maintain high productivity. In addition, this crop is disease-prone since it is propagated from cuttings; it is a semiperennial crop and monocropped over extensive areas. Hence, sugarcane growers run a relatively high risk when exchanging plant material.*

*CIRAD has been developing a quarantine centre in Montpellier over the past 20 years to obtain certified healthy cuttings.*

*Clones preselected in Guadeloupe and Barbados as well as international commercial varieties are available. The cuttings produced are distributed, by contract with CIRAD, on a yearly basis to sugarcane-growing areas in western and central Africa. In 1994, 10 sugar companies from 8 different countries thus obtained cuttings from 123 clones.*

*In addition to sealed greenhouses and thermal treatments, CIRAD is continuously upgrading the security of this quarantine through the development of indexing tests and disease assessment techniques.*

## SUGARCANE

The sugarcane genome is being mapped and cell biology techniques perfected to enhance breeding strategies. In the CIRAD sugarcane research programme, there was marked progress in developing genetic mapping, in-situ hybridization techniques, and micropropagation techniques in 1994.

### Genome Mapping

Genetic improvement of sugarcane is a painstaking task because of the complex genetic structure of cultivars—resulting from interspecific *Saccharum officinarum* x *S. spontaneum* crosses. CIRAD has been working with molecular markers since 1987 to obtain detailed information on the genetic structure of sugarcane.

The genome mapping study is being carried out with material from the selfed progeny of variety R 570 from the Centre d'essai, de recherche et de formation of Réunion. In this process, 428 markers have already been positioned, and the portion of the chromosome set inherited from *S. spontaneum* is the best-marked area on the genome.

Recombination between the two basic genomes seems to occur.

Field and greenhouse analyses of some R 570 progeny indicated that the preliminary study probably uncovered a major rust-resistance gene. Moreover, genes responsible for many variations in several agronomic traits were also pinpointed on the genetic map.

### In-Situ Hybridization

Introgression of genes from wild species is an important aspect in sugarcane breeding. CIRAD has just demonstrated that it is possible to use in-situ hybridization to differentiate chromosomes of *Saccharum officinarum* from those of the main sugarcane species used in standard introgression programmes (*S. spontaneum* and *Erianthus arundinaceus*).

The influence of *S. spontaneum* on commonly-grown sugarcane varieties can be clearly observed. Its chromosomes were differentially labelled for the elite Réunion sugarcane variety R 570; whole chromosomes derived from *S. spontaneum* and recombinant *S. spontaneum*/*S. officinarum* chromosomes were thus identified. This study is the first to highlight that, contrary to common opinion, the chromosomes derived from interspecific recombination are relatively common.

## Micropropagated Plants to Reclaim Sugarcane Plantations

Production is maintained in sugarcane cropping areas by replanting healthy cuttings every 5–6 years. In Guadeloupe, healthy micropropagated shoot tips are now planted in nurseries; this is an effective means of controlling bacterial diseases.

Following a quarantine period, in-vitro clonal propagation is carried out in Montpellier, remote from the sugarcane cropping area, thus ensuring the phytosanitary status of the material. The shoot tips are cultured under sterile conditions in liquid medium without growth stimulators or antibiotics—which limits the risk of somaclonal variation—and show a multiplication rate of three to five per month.

Enough cuttings to plant 3,000 ha in a commercial plantation can be produced within 24 months, which includes several propagation cycles in a nursery and tests to check plant true-to-typoness and quality.

Regular inspections of these plants revealed an increase in tiller numbers of up to 50%, with a decrease in stem diameters, as compared with the original plant material. This behaviour is

### INTERNATIONAL MEETING

#### First World Conference on Cotton Research

*The First World Conference on Cotton Research was held at Brisbane (Australia) under the aegis of the International Cotton Advisory Committee. This conference, organized in collaboration with the Australian Cotton Research and Development Corporation and FAO, was attended by 500 delegates from 40 different countries.*

*The main papers presented dealt with genetic engineering, cotton hybrids, soil-plant interactions, cotton plant nutrition, multiple resistance to adverse factors, growth regulators, pests (ecology, population dynamics models, crop damage and pesticide resistance) and integrated pest management.*

*CIRAD presented its cotton breeding programme and research output on cotton plant physiology, ecological aspects of major cotton pests and infestation control.*

of interest because it boosts the propagation rate and gradually disappears by the end of the propagation cycle. A study of tens of thousands of plants revealed persistence of this modification after a long period of recurrent callus formation, but this was noted in a few exceptional cases only.

## COTTON

The four main research foci of the cotton programme are: plant productivity, matching fibre quality with market demand, analysis of cotton production and marketing sectors, and environmental concerns.

### Analysis of the Cotton Sector in Mali

In recent years, there have been marked variations in cotton production and use, along with fluctuations in world cotton prices.

CIRAD aims to identify and analyse the problems on a cotton-sector basis so that tailored solutions can be proposed to cotton-producing countries. In this approach, the Department takes each function into consideration from the production stage until the cotton product is marketed; the strategies of all sectoral operators are assessed to point out economic mechanisms involved.

This analytical approach was used in 1994 to investigate the dynamics of the cotton production and marketing sector in Mali. An analysis of a century of cotton production highlighted the influence of a strategy

to increase smallholder cotton productivity while securing the market. The cotton sector has evolved with a series of interactions between sectoral operators with conflicting interests.

Analysis of data pertaining to French-speaking African countries highlighted a concomitant increase in cotton and food crop production. This phenomenon could be explained by the fact that cropping equipment introduced for cotton can be used for other crops, and by an increase in smallholder know-how resulting from cotton growing. In the framework of a contract associating the state, cotton companies and cotton producers, seed-cotton has partly been paid ex-post since 1990. This study helped identify perverse effects and proposed more efficient alternative modalities.

### **International Status of the Cotton Technology Laboratory**

The CIRAD cotton technology laboratory is becoming renowned worldwide. It represents, in collaboration with the Faserinstitut of Bremen (Germany), the International Textile Manufacturers' Federation (ITMF) on the International Cotton Calibration Standards

## NETWORKS

### **Breeding Projects in the Cotton Network**

*A meeting of breeders of the CORAF Cotton Network was held at Garoua (Cameroon) in 1994. CIRAD scientists and those from nine western and central African countries presented their research results to development agents, traders and textile industry representatives.*

*At this meeting, cotton breeders decided to undertake joint projects to unify and improve the efficiency of this CORAF network. These projects include publication of a catalogue of cotton varieties, seed exchanges between network members, and an international breeding experiment using common control plants.*

Board. Laboratories belonging to this Board characterize standard cottons used to calibrate conventional measuring instruments by laboratories throughout the world.

CIRAD has become an active member of all ITMF working groups on the basis of its fibre technology skills with high-volume instruments (HVIs), stickiness detection and analysis, and fibre maturity measurement. These groups are responsible for standardizing textile manufacturing techniques.

The thermodetector developed by the laboratory to detect honeydew contamination of cotton became a standard device in 1994. There are now 80 of these devices being used in laboratories throughout the world. Moreover, a high-speed stickiness detector prototype, which can be fitted to HVIs for grading cotton, is currently being test-checked at Cotton Incorporated (USA).

CIRAD is constantly contributing on topics of increasing importance in the world, e.g. low cotton fibre resistance to breakage and the presence of seed-coat fragments in the fibres—which reduces spinning performance and textile quality. The laboratory has developed an image analyser to monitor seed-coat fragments and is creating a model to simulate cotton behaviour during spinning.

CIRAD's involvement in standardization boards (Association française de normalisation [AFNOR], European Committee for Standardization, ITMF and FAO) helps research centres and cotton companies obtain information about the evolution of techniques and of trading quality standards. This information is of particular importance in cotton breeding.

## A New Parasitoid for Integrated Control

*Spodophagus lepidopterae* (Hymenoptera: Pteromalidae) is a parasitoid that was raised for the first time from *Spodoptera littoralis* chrysalides gathered in Madagascar. Analyses indicate that it would be a suitable candidate for integrated pest management.

This larval-nymphal endoparasitoid is highly prolific; as many as 500 parasitoids can be produced from one chrysalis parasitized by two initial parasitoids. Moreover, the first host, *Spodoptera littoralis*, is easy to raise, and *Helicoverpa armigera*, which provides it with shelter, can be stored in the chrysalis stage in diapause.

When a female *Spodophagus lepidopterae* encounters its host, a final-instar *Spodoptera littoralis* caterpillar, it follows the caterpillar in the soil to parasitize it. The whole parasitoid larval cycle occurs within the host. The parasitoid should not then be destroyed by insecticide sprays during this underground phase.

Since the adults mate inside the chrysalis host, it is quite likely that these parasitoids could survive and thrive after insertion in new biotopes.

In addition to its first host, *Spodophagus lepidopterae* parasitizes *Spodoptera frugiperda*,

*S. exigua*, *S. sunia* and *H. armigera*. In Réunion, it was recently found in *S. mauritia* chrysalides at 600 m elevation. This new parasitoid is also able to occupy a broad range of different habitats, which means that it should have no difficulty in adapting to different tropical and subtropical regions.

## Encyclopedic Cotton Protection Software

Coton Doc is an encyclopedic software program available on CD-ROM. It is a cotton pest control management tool for African regions south of the Sahara. It was designed and created by CIRAD entomologists, and developed in collaboration with the "Association des universités partiellement ou entièrement de langue française; université des réseaux d'expression française" (AUPELF-UREF).

There are four thematic modules: the plant, pests, control procedures and the 14 countries covered by the program. Coton Doc contains 1,500 pages of text, about 500 colour photographs, a bibliography, statistics and a glossary.

This educational software tool should appeal to a wide audience owing to its simplicity,

and the abundant information it provides should meet the requests of cotton specialists.



## ECOREGIONS

The ecoregional research approach favours interventions of the Department that seek to achieve sustainable development in regional areas while fulfilling regional inhabitants' needs. Projects are carried out in several types of ecosystems: savanna areas in western and central Africa, newly cultivated areas in Brazil and Vietnam, highlands in Madagascar and lowlands in western Africa. They also focus on natural resource assessment and follow-up in regions where there is a high risk of resource depletion (Cape Verde, Senegal), and on agro-industrial waste and effluent management—to tap agricultural biomass energy while protecting the environment.

## Assessment of Cultivated Savanna Areas

Statistics on cotton cropland in the Sudanian zone of Africa are often based on growers' declarations and



## PRODUCTS FOR DEVELOPMENT

### A Large Waste Treatment Unit in Mali

*In Mali, the largest Transpaille unit to process agricultural organic wastes by methane fermentation was built by CIRAD in collaboration with a local NGO named AEDR.*

*This large-scale project was developed to produce compost and energy for irrigation. It is a 50-m<sup>3</sup> capacity unit capable of processing more than 500 kg/day of strawy manure; the biogas produced provides enough energy to power a 70 hp motor pump with a pumping output of 3,500 m<sup>3</sup>/day. This Transpaille unit produces more than 50 t/annum of compost for use as fertilizer and a nursery plant substrate.*

in Burkina in collaboration with INERA. High-resolution Spot satellite data had to be used because of the small size of the crop fields evaluated. Two permanent sites, representative of most of the agroecological situations in the western part of the country, were investigated: Solenzo (80,000 ha) and Safané (220,000 ha).

Although it has not yet been possible to identify all the types of crops present, the areas covered by cotton and food crops can be calculated with a statistical precision of 90%.

The two maps drawn up (1/50,000 and 1/75,000 scale) show the spatial distribution of cropland and also provide a precise update on the situation concerning access routes and permanent settlements.

These inventory data could be used for resource management, as part of a geographical information system (GIS), if associated with other specific thematic data, e.g. physiographic units, data on ethnic groups, socioeconomic data.

An initial application in 1994 obtained an honourable mention at the international show on Spot and GIS applications organized by the Environmental

Systems Research Institute and the Spot Image company.

### Moisture Uptake in Maize Crops at Medium Altitudes

Maize cropping systems are vital in Mexico since maize is a staple food in this country. Studies carried out in collaboration with CIMMYT and the Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP) were aimed at consolidating upland maize production in plateau areas of Jalisco state where precipitation is irregular. A new maize-sowing technique involving direct drilling on crop-residue mulch was thus introduced.

A regional agricultural survey and experiments conducted in controlled conditions revealed that this technique improves moisture conservation in soil and uptake by the crop; this in turn improves yields if other critical factors are controlled. High-yielding CIMMYT maize varieties are to be introduced in 1995 as a result of these improved soil climate conditions.

### Natural Resource Inventory in an Arid Island Environment

A geographical database (1/25,000 scale) was developed to facilitate land-use planning on São Tiago island (Cape Verde).

surveys. However, it is difficult to obtain reliable data by either of these methods before the end of the crop season, and impossible to gain access to information on the spatial distribution of cotton crops.

In an attempt to overcome these problems, remote sensing was tested as a complementary statistical data source, combined with a spatial representation of the cropped area.

The study, cofunded by the French Ministère de la coopération, was carried out

## NETWORKS

**Drought Resistance**

*In 1994, one of the main priorities of the Drought Resistance Research Network (R3S) of CORAF and the Inter-State Committee on Drought Control in the Sahel (CILSS), in which CIRAD research scientists are involved, was to publish research results on this topic. A newsletter and catalogue of network scientists' publications was published and widely circulated by the network. The proceedings of an international seminar on improved management of rainfall data through a multidisciplinary water-soil-plant approach, held in Bamako (Mali) in 1991, were also published.*

*In addition, network members decided to set up a new research project, entitled "Risk and Intensification", in Mali and Burkina to be presented to the European Commission.*

This project, funded by the European Commission, was developed in collaboration with research institutes of Cape Verde and Portugal, the Instituto Nacional Investigação e Desenvolvimento Agrario (INIDA) and the Instituto de Investigação Científica Tropical (IICT).

This database, managed by a geographic information system (GIS), develops the engineering potential required to design and

follow up land-use planning projects that combine crop productivity and natural resource conservation. This data processing unit, involving several INIDA professional staff who have been trained to use analytical software in the Arc Info environment, is fully operational in Cape Verde.

The database is designed around three modules—morphometric, thematic and climatic. The morphometric data, required for the three-dimensional topological views, are pooled into files that are useful for designing land-use plans. They are managed by a digital field model generated by dual Spot satellite images with 10 x 10 m ground resolution.

The thematic data provide essential information for resource conservation. These variables are obtained by digitization of existing or created documents; they are updated regularly through field appraisals. The overall environmental description is completed with climatic information derived by interpolating selected data obtained with a measuring device.

An atlas is currently being published. Research is under way, in collaboration with INIDA, IICT and the University of Evora (Portugal), towards a thesis to assess potential applications of the technique for forecasting crop yields.

**Precipitation Resource Management in the Sudano-Sahelian Zone**

The utilization of precipitation data has to be integrated with efficient soil fertility management to ensure sustainable farming systems.

Two sites have been set up in the Sudano-Sahelian zone on the basis of research studies, one in Senegal in collaboration with ISRA and ORSTOM, and one in Cameroon with the Institut de la recherche agronomique (IRA). In both cases, water management on cultivated slopes was improved by taking a broad range of parameters into account.

In Senegal, the inhabitants of Sine-Saloum village have upgraded a slope that was seriously eroded by runoff. The crop fields were stabilized by partitioning the area with meshing, which improved moisture retention. They also modified their cropping sequences and undertook grazingland renovation, thus further enhancing water infiltration. Agricultural engineering skills were used in restoring access routes and conserving infrastructures. This development project and the results are fully illustrated in a CIRAD videocassette.

## THESES COMPLETED IN 1994

### CIRAD Scientists

**Genèse du ruissellement sur les sols cultivés du sud du Saloum (Sénégal) ; du diagnostic à l'aménagement de parcelle** [Impact of runoff on cropland soils south of Saloum (Senegal); from assessment to cropland development] by Pascal Perez; Ecole nationale supérieure agronomique de Montpellier.

**Le semis direct avec pailis de résidus dans la région de V. Carranza au Mexique ; intérêt de cette technique pour améliorer l'alimentation hydrique du maïs pluvial en zones à pluviosité irrégulière** [Direct drilling on crop-residue mulch in the V. Carranza region of Mexico; benefits of this technique for improving moisture uptake of upland maize crops in areas with irregular precipitation] by Eric Scopel; Institut national agronomique de Paris-Grignon.

**Modélisation mécaniste et fonctionnelle du bilan hydrique des cultures ; le cas des sols volcaniques du Nicaragua** [Mechanical and functional modelling of crop moisture regimes as applied to volcanic soils in Nicaragua] by Florent Maraux; Institut national agronomique de Paris-Grignon.

**Cycle évolutif de *Helicoverpa armigera* (Hübner, 1808) (*Lepidoptera*, *Noctuidae*) dans l'ouest du Burkina ; biologie, écologie et variabilité géographique des populations** [Life cycle of *Helicoverpa armigera* (Hübner, 1808) (*Lepidoptera*: *Noctuidae*) in western Burkina; biology, ecology and geographical variability of the species] by Samuel Nibouche; Ecole nationale supérieure agronomique de Montpellier.

### CIRAD Trainees

**Analyse et modélisation du développement du géranium rosat (*Pelargonium* sp.)** [Analysis and modelling of rose geranium (*Pelargonium* sp.) development] by Grégoire Vincent (France); Université Claude Bernard, Lyon.

**Utilisation des données NOAA-AVHRR pour modéliser la production primaire du mil dans l'écosystème sahélien (Niger)** [Use of NOAA-AVHRR data for modelling primary millet production in Sahelian ecosystems (Niger)] by Hassan Ouadrari (Morocco); Université Paris VII.

**Contribution à l'étude des phanérogames parasites du Burkina et du Mali ; quelques aspects de leur écologie, biologie et techniques de lutte** [Contribution to the study of phanerogam parasites in Burkina and Mali; some aspects of their ecology, biology and control techniques] by Gérard Hoffmann (France); Université Aix-Marseille III.

**Etude génétique des interactions hôte-pathogène dans le cas du pathosystème *Oryza sativa*-*Magnaporthe grisea*** [Genetic analysis of host-parasite relations in the *Oryza sativa*-*Magnaporthe grisea* pathogenic system] by Didier Tharreau (France); Université Paris XI, Centre d'Orsay.

**Contribution à l'étude des hétéroptères associés à la rotation culturale maïs-cotonnier-niébé au Togo** [Contribution to the study of Heteroptera associated with maize-cotton-cowpea crop rotations in Togo] by Wiyao Poutouli (Togo); Université Paris VI.

**Défense du cotonnier contre les insectes ravageurs ; étude d'une stratégie basée sur l'expression conjointe d'inhibiteurs de protéases et de toxines de *Bacillus thuringiensis* dans la plante** [Insect pest protection of cotton; study of a control strategy based on the joint expression of protease inhibitors and *Bacillus thuringiensis* toxins by the plant] by Véronique Le Tan-Dumanois (France); Université Paris XI, Centre d'Orsay.

**Prévention de la résistance aux pyréthroïdes chez *Helicoverpa armigera* (Hübner, 1808) (*Lepidoptera*, *Noctuidae*) en Côte d'Ivoire** [Prevention of pyrethroid resistance in *Helicoverpa armigera* (Hübner, 1808) (*Lepidoptera*: *Noctuidae*) in Côte d'Ivoire] by Thierry Alaux (France); Institut national polytechnique, Toulouse.

**Diversité génétique de *Beauveria brongniartii* et détection par amplification génique de souches pathogènes du ver blanc *Hoplochelus***

***marginalis*** [Genetic diversity in *Beauveria brongniartii* and detection of pathogenic strains of the white grub *Hoplochelus marginalis* by gene amplification techniques] by Cécile Neuveglise (France); Université Claude Bernard, Lyon.



A faded, sepia-toned photograph of two individuals in a field. One person, wearing a patterned wrap, is bent over, holding a large, shallow bowl filled with leaves. Another person is partially visible on the left. The background shows dense vegetation. The text "Tree Crops Department" is overlaid in the center in a large, black, serif font.

# Tree Crops Department





**T**he prices for many tropical agricultural products rose in 1994. Coffee holds the record, its price more than doubling, on average, between 1993 and 1994. Palm oil prices rose 40%, those of copra oil 35%, and natural rubber prices leapt 70% between January and December. Cocoa prices lag behind, but nevertheless rose by 20% over the year. This situation reversal reflects a new or increased shortage of all these products in markets where, until recently, they were in over-production.

*These shortages are in part due to the economic upswing which creates heavier demand for raw materials. But it is also the result of a levelling off, and indeed in some cases a decrease in production of coffee, cocoa, even latex, as in Malaysia. Several consecutive years of extremely low prices led many producers to slow down on investment or stop planting.*

*Today it seems likely that production will have to be encouraged, with the knowledge, however, that any promotional policy must take account of the following constraints: there will continue to be fierce competition on the world markets, entailing steep price fluctuations over the next few years, especially for oils; other agricultural raw materials or even synthetic products could take the place of tropical products; the consumer is demanding that all these products, except rubber, be of increasingly higher quality, with no guarantee that he would pay more; natural resources, especially forests, will become rarer, and therefore more protected.*

*Agronomic research can find ways of dealing with these constraints.*



## COFFEE

By July 1994, following reports of frosts in Brazil, coffee prices had trebled since the beginning of the year; they fell later, to stabilize at the end of December at double those of January.

This price increase reflects an expected production shortfall which is likely to last until 1997. The financial resources that this engenders will encourage a return to more sustainable agricultural methods and, particularly, to improved crop protection.

The main coffee pests are either soil pests such as nematodes and scale insects, or airborne pests.

Some of these, such as the berry borer and the variegated coffee bug, attack the fruit while others, such as the leaf miner or the leaf caterpillar, destroy the leaves.

Studies have been undertaken by CIRAD with PROMECAFE in America and with ISABU in Burundi to develop an integrated pest control strategy.

### Nematode Control

Severe damage is caused to *Coffea arabica* by *Meloidogyne* and *Pratylenchus*.

Considerable progress has been made in characterizing these nematodes. By combining enzymology and morphometry it was possible to identify certain *Meloidogyne* populations as

## TREE CROPS DEPARTMENT

### CIRAD-CP

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Jacques Meunier  
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Cocoa  
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Coconut  
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Breeding  
Dominique Nicolas  
Crop protection  
Dominique Mariau  
Technology  
François Challot  
Economics  
Claude Freud  
Biometrics  
François Bonnot

### Support Services

Information, documentation  
Christine Nouaille

belonging to known species (*M. exigua*, *M. incognita*, *M. arenaria*, *M. javanica*) and to reveal the existence of hitherto unknown species.

Studies were undertaken of nematode population spatial and seasonal distribution in Central America, which showed that they congregate on a plot of land, and a representative sampling method could therefore be devised.

A study of population dynamics at an altitude of 450 and 1,100 m revealed two annual peaks connected to root growth.

*Pratylenchus* can cause up to 60% tree loss within 3 years of planting. On-site chemical control is ineffective. But resistant rootstock can increase productivity five-fold.

### Berry Borer Control

The African coffee berry borer, *Hypothenemus hampei*, found its way to America, but the parasitoids which control it did not. It should be possible to control the pest biologically by introducing and breeding one of the parasitoids, *Cephalonomia stephanoderis*, and mass-releasing it. If enough *C. stephanoderis* are released, the number of fruits infested in the subsequent crop could be reduced by half.

This biological control method is undeniably advantageous on several counts: the labour costs

## PRODUCTS FOR DEVELOPMENT

### In-vitro Plantlet Production in Uganda

*At the end of 1993, the European Commission requested a technology transfer to set up a laboratory for the micropropagation of coffee plantlets on a commercial scale in Uganda. CIRAD answered the invitation to tender.*

*CIRAD was to be responsible for supplying a laboratory entirely equipped for in-vitro culture and for training Ugandan technicians and researchers in the techniques of in-vitro coffee propagation.*

*The objective is in-vitro multiplication by microcutting of six Coffea robusta clones selected for their resistance to leaf rust. Before the end of 1995, 250,000 coffee plants are expected to be produced using CIRAD's technique of in-vitro propagation by temporary immersion in liquid medium.*

represent 7% of the coffee production price, which is comparable to the cost of chemical control; *C. stephanoderis* can be bred by the producers themselves, whatever the size of their plantations. Although still less effective than well-conducted chemical control campaigns, this biological control method could be improved by repeated mass-releases.

### Leaf Miner Control

*Perileucoptera* spp., or leaf miners, bore holes in coffee tree leaves, causing them to fall. Considerable damage is done by these pests in East Africa, Latin America and India. CryIA(c) and CryIB toxins of *Bacillus thuringiensis* act effectively against *P. coffeella*. The cryIA(c) and cryIB genes coding for these toxins could therefore be used in a genetic transformation programme of the coffee tree to make it resistant to leaf miners. CIRAD and FRANCERECO (Nestlé's biotechnology research centre, Tours, France) are cooperating on the introduction of these two genes into the coffee genome. Somatic embryos and plantlets have been regenerated from transformed cells and the genes have been isolated. *Agrobacterium tumefaciens* will be used as a vector to introduce the genes into the coffee genome.



World cocoa production has remained lower than consumption for the 4th consecutive year. Widespread planting in Asia, especially in Indonesia, raised production in 1993, but it slowed in 1994. At the same time,



consumption reached a new record level of 2.5 million t. Stocks are being whittled away and currently account for less than 50% of gross annual production. In this economic context problems related to quality remain the main preoccupation for industrialists and consumers alike.

### Genetic Map of the Cocoa Tree

A genetic map of the cocoa tree was compiled from the progenies of 100 individuals resulting from a cross between two heterozygous parents. The map contains 193 markers located on 10 linkage groups, which should correspond to cocoa's 10 gametic chromosomes. The map seems to be complete, as the average distance between two markers is 3.9 centimorgans.

It should now be possible to locate chromosomal zones involved in precise character variations. The markers that tag these zones will be used for early breeding schemes and to monitor interesting characters, as well as to shorten successive breeding cycles.

The work already conducted has enabled researchers to specify regions involved in the expression of characters such as the number of ovules per ovary, bean size and resistance to *Phytophthora palmivora*. These preliminary

## NETWORKS

### Genetic Improvement of Cocoa

*At the XIth international conference on cocoa research held in Yamoussoukro in July 1993, a proposal was made to create a permanent international group of researchers interested in genetic improvement of cocoa. CIRAD contacted various international organizations and a first "International Workshop on Cocoa Breeding Strategies" was held in Kuala Lumpur in October 1994. Forty-two researchers presented 22 papers.*

*The International Group for Genetic Improvement of Cocoa (INGENIC) was formed and its objectives defined at this workshop. INGENIC, whose first chairman is a CIRAD geneticist, will encourage the exchange of scientific information and international research cooperation, organize an international seminar every 2 years with publication of its proceedings, and issue an information sheet every 6 months.*

*Interest in the project has been expressed by many international organizations, such as APPC and ICCO, as well as by representatives from the processing industries. To enable INGENIC to remain independent, it was decided that it should function on an unofficial basis until the next workshop, planned to coincide with the XIIth international conference on cocoa research to be held in Bahia, Brazil, in 1996. The theme of that workshop will be Cocoa Breeding for Disease Resistance.*

studies will continue on more and different progenies and will be expanded to include marking of the regions involved in resistance to *P. megakarya* and insects, certain agronomic characters and cocoa quality.

### Aroma Precursors and Cocoa Aroma

Cocoa quality is determined by genotype, growing environment, cropping practices, postharvest processing (fermentation and drying) and product processing, especially roasting.

The chemical reactions that take place during fermentation and drying alter the biochemical composition of the beans and result in thermal aroma precursors and "fermentation" volatiles, comprising compounds of microbiological, biochemical and thermal origin.

During the roasting process, the aroma precursors are broken down and form an additional thermal aroma; if nonfermented cocoa is roasted, it will not develop a chocolate aroma.

Final cocoa aroma is a mixture of the "fermentation" aroma and



the aroma developed during roasting and is determined by the quality of the “fermentation” aroma.

It should be possible to draw up technical options for each cocoa genotype in order to improve its aroma quality, based on findings from various studies: genotypes processed in the same way; fermentation kinetics for different cocoas; roasting parameters and their influence; thermal aroma development modelling.

### **Mastering Quality: Controlled Fermentor and Dryer**

Postharvest processing of cocoa seeds comprises two main operations on which the quality of the product depends: fermentation and drying. CIRAD is seeking to obtain reproducible quality that meets processor requirements.

Two machines, a fermentor and a dryer, have been designed to this end, with the cooperation of the Gauthier company and financial backing from ANVAR, the French Ministère de l'enseignement supérieur et de la recherche and the Hérault Conseil général.

The fermentor enables controlled and automatic fermentation; the quality of the end product conforms to consumer tastes and reduces automation workload.

The principle of the controlled fermentation can be used in existing installations; the machine is viable for plantations of 50 to 100 ha.

Artificial drying must be carefully controlled so that the fermented product does not become acidic. Studies were carried out as to how to obtain nonacidic cocoa and reduce energy costs at the same time. CIRAD devised a dryer that should do both, thanks to two novelties: drying takes place by conduction and in a closed atmosphere. It is hoped that the process will save up to 25% on energy costs. Experiments with the prototype dryer will be carried out in Mexico in 1995.

The combined fermentor-dryer will produce quality products.



## **OIL PALM**

Palm oil prices have risen considerably since 1993, due to the moderate production increase from 1993 to 1994, a time of increased demand in Asian markets, especially China.

Although the future of the oil palm sector generally seems safe, there are, or will be, regional problems: in Africa and Latin America, plantations will have

to improve their market competitiveness; in Malaysia, it will be necessary to compensate for a lack of available labour by enhancing the value of products, co-products and by-products; sustainable environment-friendly cropping must be developed. CIRAD's oil palm programme hopes to play an active role in finding solutions to these problems.

### **Africa's Palm Oil Needs**

The main African palm oil producing countries are on the western side of the continent: Nigeria, Côte d'Ivoire, Ghana and Cameroon which, along with Benin, Congo, the Central African Republic, Gabon, Guinea and Zaire, supply 1.54 million t per annum, i.e. 82% of Africa's annual production.

Over the last 10 years, an average of 14,300 ha of oil palm have been planted each year. But it will be necessary to renew and extend oil palm plantations at an accelerated rate in order to keep up with the population explosion expected in these nine countries between now and 2020—from today's 156 million to 320–360 million inhabitants by 2020.

According to a study carried out jointly by CFD and CIRAD, 30,000 to 40,000 ha of oil palm

## INTERNATIONAL COOPERATION

**Oil Palm Bud Rot in Latin America**

*Oil palm bud rot, the cause of which is unknown, can appear a year after planting.*

*In Ecuador, Colombia, Brazil and Surinam, serious damage is being caused by this disease, which has been observed on the American continent for 30 years. The pathogen and possible vector have not yet been found, despite numerous research projects, such as those conducted by CIRAD, and considerable financial backing, mostly from private companies (Palmeras del Ecuador, Palmoriente, Denpasar).*

*All the *Elaeis oleifera* × *Elaeis guineensis* interspecific hybrids planted in the zones invaded by bud rot have shown good tolerance of the disease, but in the best of cases produce 30 to 40% less oil than the selected *E. guineensis*. The genetic improvement programme will aim to transfer the tolerance of *E. oleifera* to *E. guineensis* through back-crossing.*

*Several research organizations will have to pool their efforts to discover the cause of this disease. As soon as the causal agent is found, early inoculation tests can be set up hence saving time in the genetic improvement programme. A project has been submitted for approval to the Common Fund for Commodities via the FAO and under which CENIPALMA (Colombia) would focus its research on fungi or physiological disorders as the possible causes, while CIRAD and EMBRAPA (Brazil) would concentrate on virus particles, other fungi and the long-term improvement programme. Help from private estates in Brazil, Colombia and Ecuador will be essential if the programme is to succeed.*

per year should be planted starting now, if supply is to keep up with demand in 2010–2020.

This target can be reached technically without major problems, but will require coherent and well organized regional planning to overcome current structural obstacles, the relocation of plantations where they would benefit from optimum agroclimatic conditions and upstream support for applied research activities such as selected seed production.

**Relocating African Oil Palm Plantations**

The CFD and CIRAD report on the productivity of 30-year-old West African oil palm plantations confirms that, in general, results have been well below the forecasts made in the feasibility studies.

The climate would appear to be one of the main causes as water deficits have been irregular and, on average, far more severe than those deduced from rainfall data, which seemed

encouraging at the time but had been collected over only a few years. At some sites, sunshine levels, at others, low temperatures due to altitude, seem to be the factors limiting production.

The production and climatic data collected made it possible to map extensive areas of Africa according to their potential (on a 1/12,000,000 scale). Decisions as to whether to replant the same sites with oil palm or to convert them to other crops can be taken on the basis of these maps, and new plantings that will be essential to keep up with the continent's demand for palm oil can be set up in the zones known to have the best potential on the basis of careful evaluation.

Feasibility studies will integrate such details as existing microclimates and soil composition.

**The Oil Palm and Drought**

Oil palm production is very sensitive to water deficit, which has worsened in the West African tropical zone since 1970. Production potential can also decrease to a point of no return due to tree losses in abnormally severe dry seasons.

Physiological studies of oil palm and coconut during

drought, in conjunction with the Pobé Research Station (Benin), the Senior Institute of Agronomy (Portugal), EMBRAPA (Brazil), the University of Paris VII and CIRAD, funded by the European Commission, have opened up new research possibilities.

Oil palm can adapt to dry conditions by closing its stomata, but this is detrimental to the plant's photosynthetic activity, and therefore to yields and storage of reserves. Preliminary studies have shown that, as in annuals, there is a positive relation between membrane sensitivity, total leaf lipid content and polyunsaturated fatty acid content. It might soon be possible to breed palms that are both more drought resistant and high-yielding.



## COCONUT

Planters benefited greatly from increased copra and copra oil prices in 1994, but in many countries demand outstripped supply because of low productivity. Yields could be improved inexpensively, however, simply by applying already proven research results.

### Coconut-Based Farming Systems

In Southeast Asia and the Pacific, 50 to 60% of coconut smallholders practice intercropping.

This cropping of perennials or annuals with coconut results in competition for light at crown level and for water or minerals at root level.

CIRAD recently undertook research based on the modelling of different aspects of this competition, in conjunction with NRI (United Kingdom), PCA (Philippines), NCDP (Tanzania), VARTC (Vanuatu) and PT Multiagro (Indonesia).

Precise relations were found between coconut palm density, the degree of incident radiation transmission, and yields from intercrops such as maize, sweet potato or beans in the first intercropping trials conducted in the Philippines. Of the negative relations observed, two were chosen to be followed up in field and laboratory trials: reduction of light penetration and root system competition.

As models are created for different situations, it should be possible to simulate the effect of coconut intercropping methods on crop yields, along with the economic consequences.

### Hartrot Disease

Coconut hartrot disease is a trypanosome disease which resembles oil palm *marchitez*. These intraphloem trypanosome diseases are known only in South and Central America. CIRAD pioneered research on plant trypanosomes (*Phytomonas* spp.) and set up an international laboratory network which has obtained interesting results.

Following in-vitro culture of *Phytomonas* isolated from the sap of coconut and oil palms infected with hartrot and *marchitez* respectively, isoenzyme electrophoresis revealed considerable variability of coconut intraphloem trypanosomes with no relation to geography or to host plant species. Based on these results, coconut trypanosomes can be classified into two main groups, one of which can be subdivided into two subgroups.

In addition, a *Phytomonas* was found in a rhizome plant, *Alpinia purpurata* (Zingiberaceae), in Grenada which is identical to those found in oil palm and coconut. This showed that other plants can play host to *Phytomonas*. It could be that coconut hartrot, oil palm *marchitez* and *Alpinia purpurata* wilt are not three different diseases but one and the same, whose symptoms are governed by the host plant and climatic conditions.



Lastly, an insect vector of these trypanosomes, a *Lincus*-type pentatomid bug, was found on *Heliconia*, a plant with the same morphology and growth habit as *Alpinia*. This discovery will create new opportunities for epidemiological research into these diseases.

### Protein and Probiotic Enrichment of Copra Presscake

Copra cake is a readily available and abundant by-product of the oil industry, but its low protein, high polysaccharide content renders it unsatisfactory as feed for monogastric animals.

CIRAD has developed a way of improving the nutritional quality of cake by adding two strains of filamentous fungi, thereby increasing protein content, balancing the amino acids and reducing fibre. The resulting product is rich in probiotics and increases animal feed nourishment. In addition, enzymes can be recovered from the press juices.

Enriched copra cake contains 34% protein compared with 20% in untreated cake and its amino acid composition is more balanced than that of soybean cake, its main competitor.

CIRAD directed this research, which was carried out in conjunction with ORSTOM, INRA and UAM (Autonomous

## NETWORKS

### The Risks Involved in Plant Material Exchanges

*An ACIAR (Australia) workshop on coconut was held in Taveuni (Fiji) in November 1993 to assess the research carried out by the Australians on coconut in the Pacific and in Southeast Asia from 1988 to 1993. One of the topics discussed was plant material exchanges and the risks of transmitting viroids or viroid-like molecules from one country to another.*

*Since these exchanges can play a major role in disease transmission, IPGRI asked CIRAD to take part in a network programme with ACIAR in 1994. The network is to draw up an inventory of the possible hazards involved in the transfer of coconut plant material containing these viroid-like molecules and researchers from CIRAD, ACIAR and PCA (Philippines) will be working together to set up a risk-free method for exchanging coconut plant material.*

University of Mexico) and financed by the Ministère de l'enseignement supérieur et de la recherche. Enrichment of copra cake by fermentation on solid medium would be a major step forward for animal feed in tropical zones.



## NATURAL RUBBER

The natural rubber sector has been affected by rising prices and an ongoing dispute between producers and consumers concerning the renegotiation of the International Natural Rubber Agreement. Natural rubber will remain competitive if research can elucidate the complex mechanism of *Hevea* production and can transform its results into efficient methods of development. A new step toward understanding a part of the tree which has hitherto been neglected is the study of the morphogenesis of the root system, whilst better knowledge of the physiological functions of *Hevea* has been acquired through genome mapping, the study of membrane exchanges/transfers in the latex vessels or the analysis of the molecular weight of natural rubber.

### Mapping the *Hevea* Genome

CIRAD and the Institut des forêts in Côte d'Ivoire are working on mapping *Hevea* genetically in order to develop marker-assisted selection. The first partial genome map of the species was drawn up following the study of a population

comprising 73 progenies obtained by selfing a high-yielding clone. Genetic linkage was analysed for 123 molecular markers, 108 of which were allocated to 24 groups. The aim is to constitute a map of 18 linked marker groups corresponding to the 18 basic *Hevea* chromosomes. The population characters studied were latex production and growth rate.

Around about 40 markers were studied in another population obtained by crossing the same high-yielding clone with a wild clone chosen for its resistance to *Microcyclus ulei*, a fungus that causes South American leaf blight. Disease tolerance tests are being carried out on this progeny at the CIRAD phytopathology station in French Guiana as part of the *Hevea* improvement programme for Latin America, a zone where *Hevea* cropping is limited by this endemic disease.

### **Analysis of Natural Rubber by Gel Permeation Chromatography**

Natural rubber is endowed with unique properties whose origin is as yet unclear and which manufacturers cannot find in synthetic rubbers. A study of these properties could lead to more rational use of natural rubber.

The elasticity of rubber is related to the average length of its polyisoprene chains which have been studied by CIRAD using a technique called gel permeation chromatography (GPC).

Cyclohexane was chosen as the mobile phase. This solvent, unlike tetrahydrofuran which had been used previously, is not very hygroscopic or peroxidic. An ultraviolet detector can be used in the absence of peroxides, thereby increasing detection sensitivity and ensuring better repeatability.

The GPC study of various processed natural rubber samples, of stable viscosity or not, as well as "cuplump" samples, has confirmed the influence of clonal origin, ultraviolet rays and processing methods, especially drying, on the molecular weight. The GPC-analysed samples weighed about 100 mg, which widens the scope for further investigations and for early diagnosis on young trees.

### **Latex System Membrane Transfers**

When a tree is tapped, *Hevea* laticiferous tissue expels the liquid it contains: latex. Flow is stopped due to coagulation of rubber particles in the wound. Latex is regenerated in-situ prior to the next tapping. To do this, the latex vessels must absorb mineral and organic compounds

which are necessary for biosynthesis. The transfer of these elements from outside to inside the cell involves complex biophysical and biochemical mechanisms.

Electrophysiological techniques have revealed vessels through which potassium, a main component of osmosis potential, flows in and out of the cell through the cell membrane (the plasmalemma) to regulate the water supply to the laticiferous tissue. Some of the characteristics of these vessels have been studied.

In addition,  $^{14}\text{C}$ -labelling of the sugars essential for the metabolism of polyisoprene provided an explanation of plasmalemma saccharose and glucose absorption: a sugar molecule and a proton are carried together by a specific protein constituent of the membrane (membrane transporter).

These studies were carried out in cooperation with the University of Paris VI and were financed by the Ministère de l'enseignement supérieur et de la recherche. They confirmed that latex cell homeostasis (regulation of biochemical composition, pH, oxidoreductase, etc.) and membrane system control (ions and various elements) are closely related and are very important for in-situ latex regeneration.

PRODUCTS FOR  
DEVELOPMENT

### Smallholder Rubber Growing

*The future of rubber worldwide largely hinges on its development in the smallholder sector. This is also true in Côte d'Ivoire, which looks set to become the foremost African rubber producing country in the not too distant future, and where rubber research has been supporting the sector since the very first smallholder pilot project in the country in the 1960s. In 1986, the Ivorian financial and political authorities acknowledged that research is an essential part of any smallholder project.*

*APPH, an Ivorian professional body currently responsible for smallholder supervision in Côte d'Ivoire, has called in the Institut des Forêts and CIRAD to set up a technical services structure in support of the development recovery prompted by the devaluation of the CFA franc and rising international rubber prices.*

*This support, funded by the Caisse française de développement, will take the form of training for 60–80 supervisors, using a technical frame of reference that will successively be tested in a network of field demonstration plots, adapted in the light of the problems encountered and expressed in terms that can be taken on board by the different grower categories.*

### Root System Modelling

*Hevea growth and latex production depend on the relation between its root and aerial systems.*

A preliminary study was undertaken with INRA of the different stages of root system morphogenesis in order to understand the tree's physiology.

Analysis of the morphogenetic characteristics of the different axes of the root system resulted in a typology of root morphology and anatomy, as well as in a spatial-temporal characterization of their appearance. A three-dimensional model was created according to the rules which govern the positioning of axes with typical morphogenetic behaviour. This simulation was compared with field observations and proved to comply with reality. This knowledge of root morphogenesis can be put to practical use, e.g. in optimizing planting techniques.

### THESES COMPLETED IN 1994

#### CIRAD Scientist

**Les propriétés émulsifiantes d'un oligosaccharide** [Emulsifying properties of an oligosaccharide] by Serge Laurent, Université des sciences et techniques du Languedoc, Montpellier II.

#### CIRAD Trainees

**Dynamique des populations du scolyte des fruits du caféier, *Hypothenemus hampei* (Coleoptera : Scolytidae) et lutte biologique avec le parasitoïde *Cephalonomia* (Hymenoptera : Bethyilidae), au Chiapas, Mexique** [Population dynamics of the coffee fruit borer, *Hypothenemus hampei* (Coleoptera: Scolytidae) and biological control with the parasitoid *Cephalonomia* (Hymenoptera: Bethyilidae), in Chiapas, Mexico] by Juan Francisco Barrera Gaytan (Mexico), Université Toulouse III.

**Identification de gènes de résistance à *Perileucoptera coffeella* en vue de l'amélioration de *Coffea arabica*** [Identification of genes resistant to *Perileucoptera coffeella* to improve *Coffea arabica*] by Oliveiro Guerreiro Filho (Brazil), Ecole nationale supérieure agronomique de Montpellier.

**Studies on genetic transformation of coffee by using electroporation and the biolistic method** by Jos van Bostel (Netherlands), Landbouwniversiteit te Wageningen.

**Embryogenèse somatique et régénération de plantes de cacaoyer à partir de pièces florales** [Somatic embryogenesis and cocoa plant regeneration from flower fragments] by Orlando Lopez Baez (Mexico), Ecole nationale supérieure agronomique de Rennes.

**Fécondation et développement des fruits et des graines chez le cacaoyer (*Theobroma cacao* L.) ; influence de l'irradiation du pollen et de l'intensité de la pollinisation** [Fecundation and fruit and seed development in cocoa (*Theobroma cacao* L.); influence of pollen spread and pollination intensity] by Matthieu Falque (France), Ecole nationale supérieure agronomique de Toulouse.

**Analyse du génome du *cocoa swollen shoot virus* et mise au point d'une méthode d'infection du cacaoyer** [Analysis of the *cocoa swollen shoot virus* genome and development of an infection method in cocoa] by Lynda Hagen (France), Université Paris VII.

**Cryoconservation des massifs d'embryons somatiques de palmier à l'huile (*Elaeis guineensis* Jacq.) par déshydratation-vitrification ; étude du rôle du saccharose pendant le prétraitement** [Cryopreservation of oil palm

somatic embryo clusters (*Elaeis guineensis* Jacq.] by dehydration-vitrification; the role of sugar during pretreatment), by Dominique Dumet (France), Université Paris VI.

**Caractérisation moléculaire et étude de la diversité des *Fusarium oxysporum* forme spéciale *elaeidis*, responsables de la fusariose vasculaire du palmier à huile** [Molecular characterization and study of the diversity of *Fusarium oxysporum* f. sp. *elaeidis*, cause of oil palm vascular wilt disease] by Isabelle Mouyna (France), Université Paris VII.

**Devenir du cuivre dans les tourbes de Sumatra cultivées en cocoteraies : conséquences agronomiques** [Development of copper in Sumatran peat coconut groves: agronomic consequences] by Sudrajat (Indonesia), Ecole nationale supérieure agronomique de Rennes.

**Influence du déficit hydrique sur la physiologie des palmes de diverses variétés de cocotiers (*Cocos nucifera* L.) ; évolution des paramètres hydriques, des échanges gazeux et de la composition lipidique des membranes** [Influence of water deficit on palm physiology in several coconut varieties (*Cocos nucifera* L.); evolution in moisture-availability parameters, gaseous exchanges and membrane lipids] by Anne Repellin (France), Université Paris VII.

**Extraction de l'huile de noix de coco assistée par les enzymes** [Enzyme-assisted extraction of coconut oil] by Frédérique Bertrand (France), Université d'Aix-Marseille III.

**Influence des contraintes édaphiques sur la nutrition, le développement et la production du cocotier dans les sols sulfatés acides salés ou non salés du delta du Mékong : effet améliorant d'un apport de phosphate naturel** [Influence of edaphic constraints on the nutrition, development and production of coconut in the acid sulphate soils, salinized and nonsalinized, of the Mekong delta: beneficial effect of natural phosphate input] by Diep My Hanh (Vietnam), Université Paris XII.

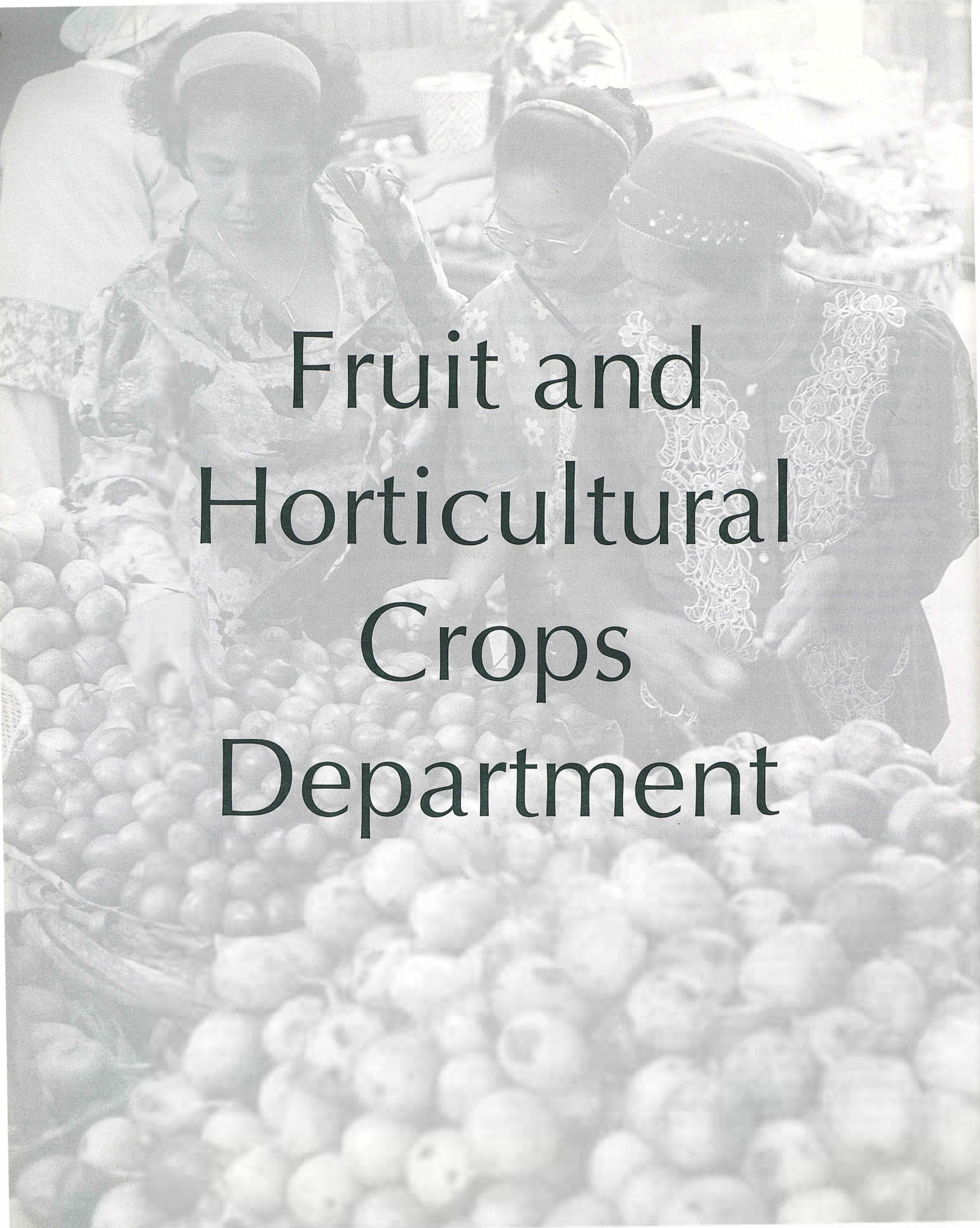
**Optimisation du rajeunissement de clones d'*Hevea brasiliensis* en vue de leur microbouturage *in vitro* ; mise en œuvre de critères morphogénétiques et biochimiques** [Optimization of *Hevea brasiliensis* clone rejuvenation for in-vitro microcutting; use of morphogenetic

and biochemical criteria] by Yolande Perrin (France), Université des sciences et techniques du Languedoc, Montpellier II.

**Mise en place de l'architecture racinaire d'*Hevea brasiliensis* ; étude comparée du semis et de la microbouture** (Structuring *Hevea brasiliensis* root architecture: comparative study of seeding and microcutting] by Yannick Le Roux (France), Université d'Aix-Marseille III.

**Canaux K<sup>+</sup> et symports H<sup>+</sup>-sucre : implication dans la régénération du latex chez les lactifères d'*Hevea brasiliensis*** (K<sup>+</sup> and symports H<sup>+</sup>-sugar channels: involvement in latex regeneration in *Hevea brasiliensis* lactiferous tissue] by François Bouteau (France), Université Paris VII.



A black and white photograph of three women in traditional attire sorting through a large pile of fruit, likely oranges, in a market setting. The women are wearing headscarves and patterned blouses. The fruit is piled high in the foreground, and the background shows other people and market stalls.

# Fruit and Horticultural Crops Department





**F**ruits and vegetables balance diets and provide food security, but production in intertropical regions is generally far below local needs. The prime objectives are thus to boost production and improve marketing outlets to supply domestic markets with this produce. In contrast, the export market for tropical fruit is currently booming and highly competitive; product quality and originality are critical factors.

For this industry, it is essential to fully define and analyse the mechanisms and interactions between those involved in the sector; between food crops and export production, and between fresh and processed products.

*Research should thus focus on providing recommendations that will enhance the market competitiveness of the industry.*

*The development of sustainable environment-friendly crop production systems for food crops (e.g. plantain) and industrial crops is an important goal for the coming years. CIRAD-FLHOR will meet this challenge by focusing much of its research on: stabilizing subsistence plantain cropping to stall forest depletion, better land-use planning and development by mixing forest and fruit trees, and organizing fruit and vegetable crop production in urban and periurban areas.*

*Efficient use of genetic resources is another major thrust of the Department. This involves optimally utilizing the existing plant diversity in varietal improvement programmes to create new plants that are better adapted to the environment and more resistant to diseases and pests, and to meet consumer requirements. There will be special emphasis on creating high-quality products, an important fruit and vegetable promotional feature for the beginning of the next millenium.*

*To ensure the success of all of these projects, the main and associated research stations in Corsica and the French overseas departments and territories (DOM-TOM) have been strengthened, new areas of cooperation have been opened in the Mediterranean basin and Asia, with increased involvement in regional and international research centres such as the Centre régional bananiers et plantains (CRBP) in Cameroon, the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Costa Rica and the Asian Vegetable Research and Development Center (AVRDC) in Asia. Moreover, network activities are being considerably expanded, especially with the International Network for Improvement of Banana and Plantain (INIBAP) on an international basis, and with the Conférence des responsables de la recherche agronomique africains (CORAF) in western Africa, Redafruthex, Tropigen and Redarfit in Latin America, and UTFANET and CLVNET in Asia.*

## CITRUS AND ORCHARD FRUIT

Ten kg of citrus fruit/person per annum are required for a vitamin-balanced diet. In developed countries, annual fresh

citrus fruit consumption can be as much as 40 kg/person and twofold higher with juice consumption. Although citrus is the most commonly consumed type of fruit in developing countries, and very inexpensive, less than 5 kg/person/annum are consumed.

## FRUIT AND HORTICULTURAL CROPS DEPARTMENT

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Citrus and orchard fruit  
*Bernard Aubert*  
 Pineapple and fruit diversification  
*Eric Malézieux*  
 Banana and plantain  
*Hugues Tézenas du Montcel*  
 Horticultural products  
*Hubert de Bon*

### Research Units

Genetic resources and  
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*Patrick Ollitrault*  
 Parasite and  
 pest biology, disease control  
*Xavier Mourichon*  
 Agronomy and  
 farming systems  
*Jean-Joseph Lacoœuilhe*  
 Economics and  
 management  
*Jean-Louis Rastoin*  
 Technology and quality control  
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 Biometrics and  
 computer services  
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### Support Services

Publications, documentation  
*Chantal Loison*  
 Communications  
*Françoise Fajac*

There are three main research objectives of the programme: reducing disease- and insect-induced losses for locally consumed varieties; improving the quality of fruit grown for export markets; seeking new types of citrus fruit and promoting other fruits.

### Developing New Citrus Fruit Varieties

Sexually incompatible species and genera can be combined by protoplast electrofusion.

This technique has been jointly developed by CIRAD and the Institut national de la recherche agronomique (INRA) with two main aims: creating citrus rootstocks with genes that are resistant to or tolerant of biotic and abiotic factors, irrespective of the degree of parental heterozygosity; and creating new types of fruit by intra- or intergeneric hybridization.

The first successful fusions were obtained with *Citrus reticulata* (mandarin) as embryogenic callus protoplasts and *Fortunella japonica* (kumquat) as leaf protoplasts. About 100 plants were successfully micropropagated. Flow cytometry was used to assess tetraploidy and their hybrid status was determined by isoenzyme analysis. With tetraploid hybrids, it should be possible to produce mandarin cultivars with certain kumquat qualities, e.g. aroma, edible skin,

longer cropping season and cold-resistance. These tetraploid hybrids will also be crossed with diploid mandarins to obtain seedless triploid cultivars.

Six other electrofusions are currently being propagated from mandarin: orange, pomelo, lemon, citron, *Poncirus trifoliata* and *Severinia buxifolia*.

The latter cross (*C. reticulata* x *Severinia buxifolia*) should produce rootstock with traits of particular interest for Mediterranean growers, i.e. tristeza-resistance, salt- and high pH-tolerance.

These new types of citrus fruit and rootstock will mark the beginning of the third millennium. They will soon be tested in a multilocation research network for their performance potential under

## PRODUCTS FOR DEVELOPMENT

### Borojo, a New Fruit for the Agro-industrial Sector

*In Colombia, there has been a sharp rise in the consumption of borojo (Borojoa patinoi), a fruit of the Rubiaceae family. This crop is currently grown on about 3,000 ha in this country.*

*The University of Cali and CIRAD are collaborating in a study, funded by the European Commission, on borojo and its potential use in the food industry.*

*Analyses revealed the exceptional nutritional qualities of this fruit; it is a high source of energy, and rich in proteins, essential amino acids, phosphorus (more than 150 mg/100 g pulp) and B vitamins.*

*Borojo had not been used previously in the food industry because of the very high pulp viscosity. This drawback was largely overcome through a liquefaction process with exogeneous enzymes, which substantially reduced the viscosity so that it could be added to many dairy products. Tests on experimental material were successful and a factory managed by a cooperative group has just started operations, with an output potential of 500 t/annum of borojo yogurt.*

Mediterranean and tropical conditions.

### Promoting Corsican Clementines

Corsican clementines have, until now, been easily identified on European markets by the stem and leaf that are left on the fruit after picking, but this feature is no longer unique. Clementine growers are therefore hoping to create a new image for their product. To assist them in achieving this goal, a study of this fruit's "quality"—broadly defined as meeting the needs of all of those involved in this industry—was begun in 1994 in collaboration with the Department of Agriculture of Haute-Corse, the Departmental Agricultural Directorate, INRA, and



## PRODUCTS FOR DEVELOPMENT

### Litchi Conservation

*Only red litchis are appealing to consumers. A process involving thermal shock and a natural antioxidant has just been perfected which enables the fruit to maintain its characteristic colour for several weeks. This new process could be substituted for current sulphur treatments that leave traces of chemical in the fruit.*

### Fruit Juice Conservation

*Small-scale units, designed by CIRAD in partnership with a French manufacturer, for processing and packaging fruit juices for local markets are now set up in several African countries. In 1994, a Ghanaian fresh pineapple producer-exporter ordered a unit to process fruit that could not be exported. CIRAD thus developed a thermal treatment and packaging process for long conservation of fruit juices in attractive and inexpensive triplex aluminium bags.*

the Centre national du machinisme agricole, du génie rural, des eaux et des forêts (CEMAGREF).

The results of an ecophysiological study of processes that lead to high-quality fruit should pinpoint indicators that will help growers in making decisions on when to begin irrigating, etc.

An analysis of cultural practices and their effects on quality revealed wide differences in growers' strategies. For instance, an orchard can be harvested once, or in several steps, depending on the priorities, i.e. costs or homogeneous ripeness (quality). During the 1994 harvest season, representative samples were obtained from 500 Corsican citrus farms so that recommendations could be tailored to their diverse objectives.

A survey commissioned by marketing agents and consumers was conducted in two French regions where clementines are popular, Provence-Alpes-Côte d'Azur and Ile-de-France. Small Corsican clementines were found to be more appreciated in southern France where they were recognized by two-thirds of all consumers, than in the Paris region where only one-seventh of consumers identified this specific product.

Corsican producers could use the results of these studies to specify the intrinsic qualities of these clementines (taste, sweetness, colour, etc.) and determine cultivation techniques required to attain them. These elements could then be used as an incentive in negotiations with distributors and state authorities towards creating a label of origin or obtaining a

certificate of quality for this product.

### Natural Aromatic Mango Concentrates

Mango harvest surpluses are often lost due to a lack of suitable small-scale processing techniques to stabilize this fruit. Since 1994, the European Commission has been funding a project to promote the use of mangoes and the creation of local processing units in developing countries. There are six partners involved: CFTRI (India), IFRPD and the University of Chiang Mai (Thailand), the University of Nottingham (UK), INRA and CIRAD (project coordinator). Aromatic mango concentrates are thus being developed that will be labelled as having "natural flavour".

A novel technique is being used, involving enzymatic liquefaction of mango pulp. Enzymes were formulated, according to the results of cell wall composition analyses, which are more suitable for breaking down mango cell walls than commercially-available enzymes. In some conditions, 80% liquefaction can be obtained, as compared with 50% with standard enzymes.

The juice is then clarified by tangential flux microfiltration through a mineral membrane. An experimental pilot unit has been



designed by CIRAD and assembled by TIA, a French manufacturer. The microfiltration parameters were optimized to obtain a top quality product at a high output rate. Two research scientists from CFTRI and IFRPD are being trained in CIRAD laboratories on the structural and enzymatic biology of mango pulp. They will be in charge of modifying the pilot unit according to conditions in their respective countries.

The next step of the project will be to develop a high quality mango concentrate.

This 4-year project—which combines basic biochemical research, perfecting processing techniques and exchanges of know-how—is exemplary in many ways. There are also many affiliated activities, such as the development of a mango pulper, designed by CIRAD in collaboration with the Auriol company.

## PINEAPPLE AND FRUIT DIVERSIFICATION

World pineapple production is currently above 12 million t/annum, 20% higher than at the beginning

of the 1980s. The fresh pineapple market is now quite saturated after a very fast initial growth period. In this context, high quality pineapples, novel varieties and special processed pineapple products have the best market prospects. The increased development of other tropical fruits is another reason to diversify the pineapple supply to urban markets. This Programme is thus specifically focused on plant improvement, varietal adaptations and technological aspects of the pineapple industry.

### Protecting Pineapple Genetic Diversity

CIRAD is involved in a project to maintain fruit diversity in Andean and Amazonian regions; it is being carried out in collaboration with: the International Plant Genetic Resources Institute (IPGRI), where a CIRAD expert is posted; Tropigen, an Amazonian genetic resources network; Redarfit, an Andean genetic resources network; and national research institutes of Bolivia, Brazil, Colombia, Peru and Venezuela.

The last European Commission-funded trip that was organized to collect pineapple germplasm took place in southern, southeastern and central Brazil in 1994. The collected material was disseminated to two important germplasm collections managed by

### PUBLICATION

#### The Protection of Tropical Fruit after Picking

*Tropical and subtropical fruits are increasingly popular on the market and their sales and diversity continue to increase. European markets, initially interested in citrus fruits, pineapple, banana, avocado and mango, are now the outlet for litchis, papaya, passion fruit and cashew nuts. But which parameters should be used to choose these fruits from far-away places? How should they be stored and packaged for transport while still preserving their quality?*

*With the title La protection des fruits tropicaux après récolte (The protection of tropical fruit after picking), this book, published by CIRAD with the support of COLEACP, describes the experience gained over more than 20 years in the field of fruit preservation. Aimed at those involved in the tropical fruit industry—researchers, growers, exporters, importers and consumers—it describes in detail for about 40 fruit the physiological changes and the fungal growths which may occur after picking. The book also describes for each fruit the best protective methods to be employed (optimal storage temperature, relative humidity and atmosphere, and physical and chemical treatments) in compliance with the legislation in force.*

## PRODUCTS FOR DEVELOPMENT

### Candied Pineapple

*Candying, a fruit preservation technique whereby the fruit is soaked in sugar syrup, is a good way to upgrade pineapple that is not good enough for export. In Colombia, CIRAD-FLHOR and the University of Cali have developed a candying procedure with optimized technical parameters, i.e. blanching time, solute additives, syrup formulation, soaking times in different media and aromatization. One unique aspect of the procedure is that a sugar solution is used instead of water for the blanching step, hence the standard initial candying bath at 25°Brix is unnecessary. The candied pineapple obtained by this technique is highly appreciated and has a long shelf-life.*

the Centro Nacional de Pesquisa de Mandioca e Fruticultura Tropical (CNPMT) in Brazil and CIRAD in Martinique which now comprise about 800 accessions each. This was a crucial operation since pineapple genetic resources are eroding as a result of human development in this fruit's indigenous areas and of genetic diversification.

These collections are now being assessed and common descriptors have been developed under the aegis of IPGRI. The goal is to obtain resistance to *Fusarium moniliforme* var. *subglutinens* and black spot disease, caused by *Penicillium funiculosum*. These genetic resources are also tapped by plant breeders seeking unique traits to create new pineapple varieties.

### New Fruit Crops in Réunion

CIRAD-FLHOR, at the request of local authorities and funded by the European Commission, has launched a programme to diversify farming systems in Réunion. It is hoped that the results will help farmers in the Hauts de l'Est and Nord-Est regions of Réunion to overcome the farming crisis, and thus keep them from abandoning their farms.

With the aim of prompting rapid development, about 20 smallholders are participating in a research project on innovative

fruit crops and cost-effective farming systems. Rare and introduced species are being studied in test plots where planting began at different elevations in 1992. The very wet climate of Réunion (up to 10 m/annum precipitation) is a determining factor in this investigation.

The strawberry guava (*Psidium cattleianum*) is well adapted throughout the region, and judicious fertilization could enhance its growth. The cabbage palm grows well at low to average elevations. Passion fruit varieties

(or granadilla, *Passiflora edulis*) have been highlighted in various zones. At 1,000 m elevations, for instance, the purple granadilla yields more than 13 t/ha of excellent quality fruit. However, collar rot is still a serious disease problem which could be overcome if studies to find a resistant rootstock are successful.

Other types of fruit are being assessed on small test plots, i.e. tree tomato (*Cyphomandra betacea*), Cape gooseberry (*Physalis peruviana*), mountain papaya (*Carica montana*) and pejobaye (*Bactris gasipaes*), a quick-growing palm which is cultivated for its palm hearts and fruit.

Tests are under way on storage techniques and strategies for marketing these fruits. For the strawberry guava, optimal ripeness and packaging in film-sealed trays are being studied.

### Promoting Export Fruit Production

The Andean region has a high fruit development potential. Many indigenous fruits are consumed on the farms and generally very few are exported. The low mean growth rate of the export market (3–4%, but 18% for papaya) could be improved. There are even a few striking successes, such as that of Colombian passion fruit

concentrate which now has a 70% share of the world market.

The Redafruthex network has just been founded to promote export fruit production through an information system and development of specially adapted postharvest techniques. This network brings together agricultural research institutions from five Andean countries: Bolivia, Colombia, Ecuador, Peru and Venezuela. It is supported by the Instituto Interamericano de Cooperación para la Agricultura (IICA) and CIRAD, which acts as the scientific coordinator.

Direct support provided for fruit producers in the Cauca valley of Colombia, where sugarcane is generally monocropped, is a good example of successful crop diversification and promotion of export crop production. CIRAD-FLHOR is providing support in setting up a pineapple industry. The main agronomic aims are to reduce labour and input costs. For the same yields, fertilizer quantities were reduced by 10%, every third application was eliminated, and the fertilizer is now applied in a more practical solid form. Moreover, recommendations have been proposed with respect to storage infrastructures, packaging choices and fruit transport.

In Africa, similar work on the booming export pineapple sector in southern Ghana is under way. This

## INTERNATIONAL MEETING

### Caribbean Pineapple

*In the Caribbean region, crop diversification is required to stimulate the sugarcane-dominated agricultural sector. Pineapple should be promoted to meet the needs of the new markets opened by tourism. Hoping to foster the development of local varieties, IICA and CIRAD organized a seminar in March 1994 on pineapple production in the Caribbean region; it was attended by sponsors and 60 research scientists and producers from 10 different countries.*

crop is being promoted to diversify natural rubber and cocoa monocropping. This involves developing cropping techniques, training, demonstration activities and technical information, with the aim of rationalizing cropping and storage for the potential export of high quality fruit.

## BANANA AND PLANTAIN

Annual world banana production is 70 million t, of which 10 million t are sold on international markets. World plantain production is estimated at 15 million t/annum. Since bananas and plantains

are seriously affected by pests and diseases, research programmes aimed at overcoming such problems are given priority. CIRAD-FLHOR is developing environment-friendly cropping techniques and plant breeding systems to obtain more competitive crops. The Common Organization of the Market for Bananas regulates conventional banana market flows in Europe under the slogan "produce high quality bananas better". CIRAD is addressing this objective by seeking new disease- and pest-resistant varieties of bananas that will appeal to consumers.

### Assessing "Soil Fatigue" in Banana Plantations

Banana root parasites are the cause of what banana growers call "soil fatigue". It is now known that this parasitism is due to both the nematode *Radopholus similis* and the fungus *Cylindrocladium pteridis*, which are being studied in Martinique and Guadeloupe.

This soilborne fungus survives in the form of microsclerotia. The virulence of this fungus was demonstrated by inoculating young healthy banana plantlets with in-vitro cultured microsclerotia.

Sampling confirmed the presence of *C. pteridis* in the roots of banana plants growing on Ferrisols (in 45% of cases), on ferrisialic soils



(26%) and on Vertisols (7%). This indicated that soils with low exchangeable bases are more favourable for the fungus.

The pathogenic activity of *R. similis*, *C. pteridis*, and their respective roles in cases of dual parasitism were studied in controlled experiments carried out with CRBP in Cameroon. It was found that, following an initial trial propagation period during which very few symptoms were noted, the nematode caused a proliferation of necrosis that ensheathed 40–60% of the root surface within 3 months. At the same time, the fungus infested the plants quite early and then steadily progressed (40–50% of the root surface in 3 months), visible as thick lines and oblong stains. This dual parasitic infestation was thus characterized by early fungal damage, a progressive increase in nematode attack sites, with ensheathing necrosis spreading rapidly over the whole banana root system. However, it is not yet clear whether this is a case of synergetic parasitism.

Fallowing and crop rotation are being investigated as possible techniques for systematic control of *R. similis* in particular.

These European Commission-funded studies are being carried out as part of a joint project with the Université de Louvain-la-Neuve (Belgium), WINBAN in Saint Lucia,

## PRODUCTS FOR DEVELOPMENT

### An Organic Banana from the West Indies

*IDN 110 is a banana variety bred by CIRAD in Guadeloupe which shows good disease resistance. It is being successfully cropped by one grower under certified organic farming conditions. This very early cultivar, renamed Petit Michel, now yields 25 t/ha/annum, with a potential production capacity of 40 t/ha/annum. It is exported to metropolitan France and its miniature size, excellent taste and organic label appeal to consumers. Other varieties are now being tested with the support of the producers' group Karubana.*

CRBP in Cameroon, the Université d'Angers (France), INRA and CIRAD.

### Black Leaf Streak Disease: a Warning System for Smallholders

Black leaf streak disease, caused by *Mycosphaerella fijiensis*, is one of the most serious leaf diseases of banana. A warning system specifying suitable fungicide treatment times has been developed by CIRAD-FLHOR. This system, based on bioclimatic data, was proven to be highly efficient in areas where bananas are grown for export (Guadeloupe, Martinique, Côte d'Ivoire, Cameroon and the Philippines).

The method was adapted for plantain smallholders in Costa Rica in collaboration with CATIE. A biometeorological warning system, based on accrued rainfall duration for a given time lapse and on observations of the first development stages of the disease, was designed after correlations were established between the epidemiology of the disease and climatic factors.

This new, simple, rapid and inexpensive system has a 2-week forecasting range, thus enabling growers to treat the disease at stages when it is most susceptible to fungicides. It has been tested in three banana-growing areas in collaboration with the Ministry of Agriculture and Livestock Production of Costa Rica. Producers compared it with their conventional control technique of treating the plants on a monthly basis, regardless of the extent of infection. The new system eliminated three treatments per year in some plantations.

In the fourth region of Margarita, where plantations were previously treated every 15–22 days, yearly treatments were reduced by two-thirds. Banana producers were also advised that low volume spraying could be used for the treatments.

In the light of these promising results, the French Ministère des affaires étrangères, the sponsor, is considering extension of the

project to control the disease elsewhere in Latin America in plantain farms.

### **New Banana Hybrids**

Triploidy is the ideal ploidy level for bananas because parthenocarpic (seedless) fruit can be produced. In a European Commission-funded genetic improvement programme, CIRAD created, for the first time, triploid hybrids that can be used to produce bananas for local consumption or export.

In breeding tests in Guadeloupe, certified disease-free cultivated or improved diploid banana plants were treated with colchicine in order to double the chromosome sets. The resulting tetraploid plants were then crossed with a diploid variety to obtain an improved triploid hybrid. Chromosome analyses in 650 of these hybrids perfectly confirmed the theoretical chromosome patterns.

IRFA 909 was one of the first triploid sweet banana varieties created. This vigorous hybrid has excellent ratooning, a short growth cycle (about 340 days) and nine hands (14 kg) form the bunches produced in the first cycle. The fruit skins are thicker than those of standard sweet bananas, therefore they stand up well during handling. The white pulp is as firm as that of cv Cavendish, with a slightly acidulous and very appealing

sweet taste. IRFA 909 was assessed by CRBP in Cameroon for its resistance to black leaf streak disease; it will soon be tested with other strains in CIRAD's laboratories in Montpellier. Its resistance to Panama disease (*Fusarium wilt*) is to be investigated by the Queensland Department for Primary Industries (QDPI) in Australia.

## **HORTICULTURAL PRODUCTS**

Vegetables are still not fully integrated in international marketing circuits, including those from developing countries. Nevertheless, these are important staple foods, even in parts of the world such as Africa where vegetable consumption is supposedly quite low. It is now essential to increase vegetable production, while regulating distribution to markets, to meet the needs of expanding urban populations; these are the prime objectives of the Horticultural Products Programme. Ornamental plant cropping is also of interest for diversifying DOM-TOM export economies. A research project is under way in Martinique to support this development.

### **Vegetables in African Diets**

What are the factors that hinder improving the supply of vegetable produce to urban African markets? Analyses of the horticultural sector conducted in the Congo, Central African Republic, Madagascar, Guinea Bissau and Cameroon provided important results for orienting future research programmes.

Vegetables, contrary to common opinion, are essential staple foods. They account for 15–20% of household food budgets, and when there is a slump in purchasing power, consumers stop buying meat and fish before vegetables. Some vegetables are consumed more than four times weekly, e.g. cherry tomatoes, onions, various species of leafy (or pot-herb) vegetables.

Household vegetable requirements, although very important, are far from being met because of seasonal market shortages. Despite the many different vegetable supply sources—intraurban and periurban crops, often self-sown and not robust, and crops from villages further away—the drawbacks have not yet all been overcome.

Intraurban vegetable cropping systems require little start-up capital but they are labour-intensive and farmers must be technically skilled and equipped.



Vegetable species are chosen according to farmers' cash potential and market risks. Short-cycle vegetables provide almost daily income, while longer-cycle vegetables bring in high revenues on a more periodic basis. Hence, it is a speculative operation to grow solanaceous vegetables due to the cropping risks involved.

Support for the horticultural sector should help to regulate vegetable supplies through improvements in transport infrastructures, assist cold-storage companies, and provide wholesaler protection, better storage conditions and information access. Agronomically, this support involves plant improvement for adaptation to climatic conditions along with pest and disease control during the hot wet season.

### Parasitoids Against Pests

Chemical treatments to control insect pests of vegetable crops can be limited through the use of parasitoids (insects that feed on the pest until its death). There are many advantages: cost-effectiveness for the farmer, consumer protection, especially for short-cycle vegetables, and environment conservation. Two studies under way on this topic are described below.

In Brazil, a study focused on controlling the cabbage pest

*Plutella xylostella* is being jointly conducted by the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) and CIRAD. The association of two types of biological control is being assessed. The research is aimed at determining whether spray treatments with *Bacillus thuringiensis*, a biopesticide that is safe for humans, affect the survival of *Diadegma* sp., a parasitoid that feeds on *P. xylostella*. The initial results have shown that biopesticide treatments carried out during substantial pest outbreaks do not affect the natural activity of *Diadegma*. However, during minor outbreaks, treatments with a normal *B. thuringiensis* dosage could jeopardize *Diadegma* populations.

In Réunion, two leaf miners, *Liriomyza trifolii* and *L. huidobrensis*, cause serious damage to many vegetable crops. Studies on two parasitoids, *Opius dissitus* and *Hemiptarsenus varicornis*, carried out in CIRAD's laboratories in Montpellier, revealed that they can jointly parasitize *Liriomyza* larvae without competing; they have also been proven effective in the field. Farmers intending to treat other pests have thus been advised to use only chemical pesticides that will not affect these leaf miner parasitoids.

### Improving Potato and Onion Yields

Considerable yield differences have been noted in fields cropped with potato and onion in southern Réunion. Follow-up work based on methods for studying crop yield build-up processes was carried out in collaboration with the agricultural department. The aim was to pinpoint different aspects of operational sequences that could be adjusted so that farmers could increase their productivity.

Potato yields vary between 10 and 34 t/ha (mean 23 t). The climate is responsible for these deviations. Corrective magnesium fertilization is required in a quarter of the fields. The banked soil technique also has a marked impact on yields; the surface area of each banked soil section must be at least 500 cm<sup>2</sup> to be able to obtain 23 t/ha yields. Finally, the vegetation index (the extent of the vegetation cover multiplied by the coverage time) is directly correlated with yields. This index is dependent on the crop variety and efficient cropping practices, and should be as high as possible.

Mechanization of onion cropping is to be promoted, e.g. direct drilling, mechanical uprooting, ventilated bulk storage, but between-field yield variations (9–38 t/ha) should be taken into account. Lower yields are obtained with direct-drilled crops (mean

21 t/ha) than with those that are started in the nursery and transplanted (mean 27 t/ha). For the Réunion cultivar Châteaueux, it is critical to adjust the planting densities at the end of the vegetative growth cycle of the onion. Further recommendations focus on avoiding soil compaction during tillage, maintaining soil pH levels above 5.5, and controlling weeds and diseases.

**Contribution des endomycorhizes à la production de plants micropropagés d'ananas (*Ananas comosus* (L.) Mer.)** [Effects of endomycorrhiza on the yield of micropropagated pineapple (*Ananas comosus* (L.) Mer.)] by Jean-Philippe Guillemin (France); Université de Bourgogne, Dijon.

#### THESES COMPLETED IN 1994

##### CIRAD Scientists

**Etude de la structure des populations, par RFLP, de *Mycosphaerella fijiensis*, agent responsable de la maladie des raies noires des bananiers** [RFLP analysis of population structures of *Mycosphaerella fijiensis*, the causal agent of black leaf streak disease in banana] by Jean Carlier; Université Paris XI, Centre d'Orsay.

##### CIRAD Trainees

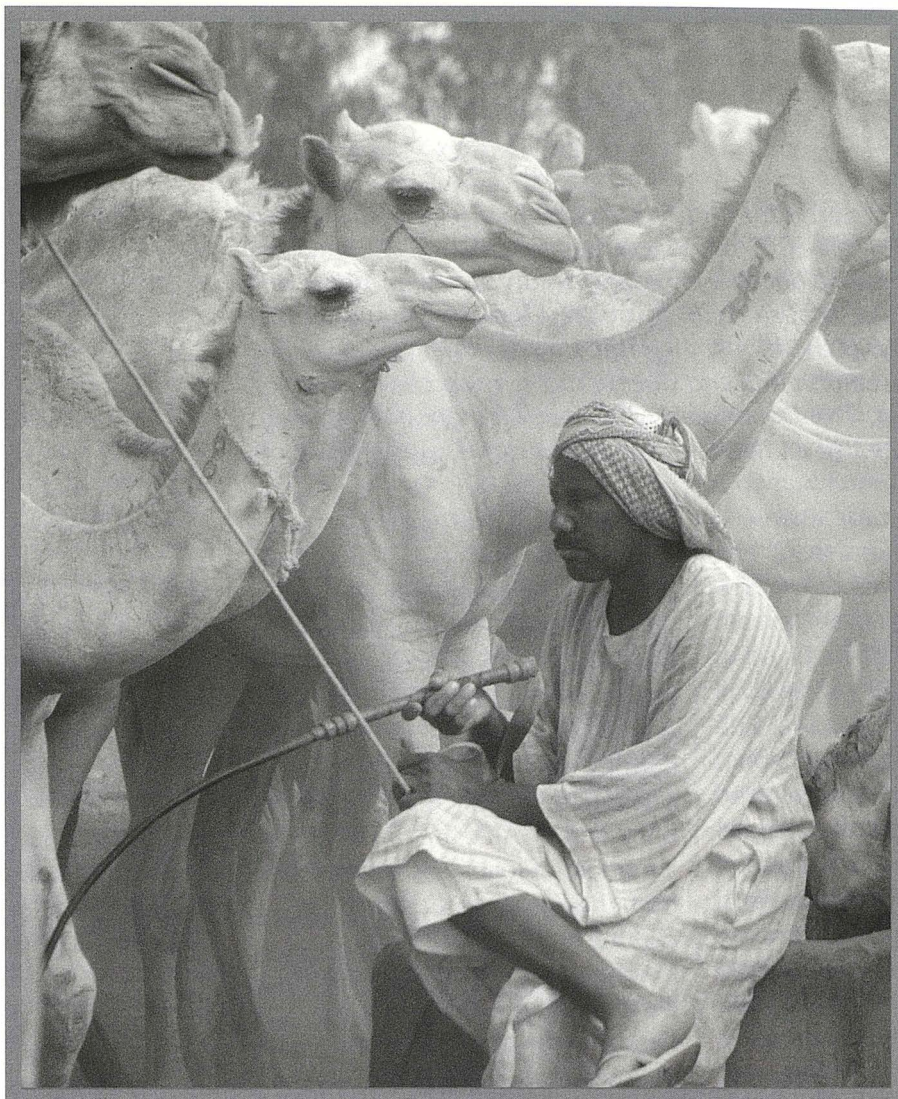
**Etude de la diversité génétique des bananiers *Musa* sp. à l'aide de marqueurs de type RFLP** [Analysis of genetic diversity in *Musa* sp. bananas using RFLP markers] by Françoise Carreel (France); Institut national agronomique de Paris-Grignon.

**Variations induites par la culture *in vitro* des bananiers (*Musa* AAA, cv Grande naine) ; éléments de caractérisation morphologique, cytologique et hormonale (GAs)** [Variations in banana (*Musa* cv Grande Naine, AAA) induced by in-vitro culture: morphological, cytological and hormonal (GA) characterization factors] by Jorge A. Sandoval (Costa Rica); Université Montpellier II.



Livestock  
Production and  
Veterinary  
Medicine  
Department





**T**he work of the Livestock Production and Veterinary Medicine Department (CIRAD-EMVT) was marked by two major events in 1994: preparations for the imminent transfer of the Department from its headquarters outside Paris to Montpellier, and its evaluation from a scientific standpoint by an external panel of examiners.

Thanks to its newfound proximity to other CIRAD departments in Montpellier, the Department was able to draw up a scientific programme including livestock, forestry and agronomy specialists. This multi-disciplinary programme should be functional by the end of 1995, at which time the Department will have left Maisons-Alfort.



The external panel began their enquiry in March 1994 and presented their conclusions to the CIRAD Scientific Advisory Committee in December. Their enquiry became the opportunity for researchers and directors to undertake a basic rethink of the Department's structure. Following their recommendations, the Department undertook to create trans-programme research units and devote more resources to work on the African continent. The Department will develop modelling methods and take more account of all livestock-based industries, and particularly product processing.

## FEED RESOURCES

How can livestock be better nourished in tropical regions without destroying the often fragile balance of the natural environment? This is a central question for all researchers. To proceed more rationally, several approaches need to be combined to evaluate the effects of herding on natural resources, develop methods for studying herd migrations in detail and propose management schemes which integrate food cropping, herding and forestry.

### **Herding and the Environment: How do they interact?**

Livestock herding is often accused of being the source of many ills that befall our planet today: deforestation, desertification, soil erosion, water pollution, global warming, etc. But what are the

actual effects of different forms of livestock herding on vegetation, soil, water and the atmosphere? How can they be quantified? A study of the impact of livestock herding on the environment, coordinated by FAO, the World Bank and USAID, and financed by a number of loans, including those from the European Commission and the French Ministry of Cooperation, attempts to address these questions. The study was based on the results of work carried out over the last 25 years.

CIRAD was called on to contribute early in 1994 by exploring two of the nine environments where this interaction is considered to be significant: pasture lands and forests. CIRAD also studied four of the 10 defined production systems: two in humid tropical zones (free range herding and mixed herding-cropping system), two in arid zones (free range herding and mixed herding-irrigated cropping system).

About 40 qualitative or quantitative, physical, biological or

## LIVESTOCK PRODUCTION AND VETERINARY MEDICINE DEPARTMENT

### CIRAD-EMVT

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Deputy Director  
*André Martin*  
Research Director  
*Didier Richard*  
Programme Director  
*Philippe Lhoste*  
Development Coordinator  
*Léon Leteneur*  
Administrative and  
Fiscal Director  
*Jean-Vital Decloquement*

### Research Programmes

Feed resources  
*Bernard Toutain*  
Animal resources  
*Dominique Planchenault*  
Livestock production systems  
*Philippe Lhoste*  
Aquaculture and fisheries  
*Jérôme Lazard*  
Infectious and  
parasitic diseases  
*Jean-Jacques Tulasne*

### Support Services

Education and training  
*Gérard Duvallet*  
Documentation  
*Geneviève Thierry*  
INFORM and cartography  
*Isolde de Zborowski*  
Publications  
*Dominique Lasserre*

socioeconomic variables were defined and ranked according to their specific relation to herding activities. However, methodological problems arose when these were applied to the fields under study and, although scientists have tools for defining ecosystems and measuring their evolution, they lack precise criteria for assessing the impact of herding activities on environmental change or for ranking natural and man-made factors.

An analysis of herding systems was used to define their positive and negative effects on natural resources. Well-managed herding, practised along with crop production, improves the sustainability of the cropping systems and adds value to the plant biomass. Other factors are involved in environmental degradation: several consecutive years of drought in a semiarid zone, excessive deforestation or ill-conceived land management in a humid or subhumid zone. In these cases, the role of herding becomes secondary.

### **Sustainable Management of Forage Resources**

Range lands are usually heterogeneous and are either overgrazed or underused, according to their location, the plant life or the season. CIRAD studied forage resources and

#### **PUBLICATION**

##### **Djibouti's Vascular Plant Flora**

*Djibouti was virtually unknown to botanists until 1971, and even today the albeit endangered vegetation of this region of Africa is not well known. La flore des plantes vasculaires de Djibouti, published by CIRAD in 1994, fills some gaps. There are 783 species described in two volumes illustrated by drawings or colour photographs. The first volume sets out vegetation in Djibouti and provides species determination keys. The second, which is divided into two parts, provides more information about the plants' taxonomy, their ecology, their uses, and the etymology of plant names.*

livestock grazing in various environments, in order to understand and remedy these imbalances. The results are interesting not only because they are directly applicable to management of the grazing routes but also because of the methodological knowledge acquired.

In Chad, where a programme was conducted in association with the Farcha Laboratory financed by the European Commission and the FAC, seasonal forage was collected over 3 years at four test sites in the Sahel. Available forage was measured 4 times a year. In order to assess the yields of 12 woody plant species, allometry

of trees and shrubs was refined or adapted to give ratios between their dimensions and their foliage biomass during peak vegetation periods. Leaf growing cycles were also studied. Lastly, the biomass percentage accessible to livestock was calculated: this is the ratio of crown volume, seen as a simple geometric form, to branch height and "penetrability". The quantity of woody fodder at the start of the dry season was thus calculated to be 40 to 480 kg/ha; its accessibility was 15 to 35 kg/ha. This is scanty compared with fodder grasses, which produce between 600 and 4,000 kg/ha. However, a study of feeding behaviour in domestic ruminants showed that this foliage biomass can supply up to 85% of protein intake according to the type of animal, location and season. Nutritional deficiencies were assessed and supplement standards were established on the basis of these studies.

In Senegal, 16,000 ha of Sudano-Guinean forage resources were mapped by CIRAD and ISRA to a scale of 1/12,000. The map distinguishes cropped zones and 12 vegetation types, defined according to structural and phytosociological criteria. This map was compiled using geographic data software and shows night stopovers, watering holes and the routes travelled by

livestock between these fixed points. Data concerning bovine eating habits over time and space can be compared with forage availability and herding customs. It is hoped that this will help explain the differences observed in yield between herds bred under apparently identical conditions. Livestock feed supplements could be foreseen and land management schemes drawn up, especially for the forests, where 40% of pasturing takes place, and which contain about 10 of the major forage species.

In Zimbabwe, studies are being carried out by CIRAD, the Ecole normale supérieure and CNRS on competition between bovines and wildlife for forage resources. The study is being conducted on a 60,000-ha ranch belonging to the Agricultural Development Authority (ADA). Methods have been devised to rapidly quantify tree fodder based on simple criteria such as "greenness" and to study animal feeding and roaming habits. The results will be used to manage the ranch in accordance with the livestock's needs and conservation of the environment.

### **Planning of the Irrigated Area of Gouère**

Construction of the Diama dam on the Mauritanian bank of the Senegal River has changed the

environment and, consequently, the living conditions of the local population. Croppers and herders, who used to grow rice and herd livestock according to the flooding and ebbing of the river, now dispute access to land and water. The national Société de développement rural and the French development bank (Caisse de développement) have asked CIRAD forestry and cropping-herding experts to study ways of improving the land management of this 11,000-ha area.

The potentials of the area were inventoried and mapped on a 1/50,000 scale showing the areas best adapted to rice cropping, vegetable farming, tree growing, grazing land, forests and those to be left fallow.

Technical proposals give priority to easily irrigable land to be used for rice cropping, since this generates the most revenue. Land which is more difficult to irrigate would be given over to grazing (forage cropping), tree or vegetable growing. The bourgoutières (grazing of *Echinochloa stagnina*) will be protected and improved.

These recommendations are accompanied by an extensive farmer training programme which includes the drawing up of an irrigation schedule, learning the techniques of forage cropping, the regulations governing tree

farming or the laws concerning the environment. The aim is to provide each farmer with the tools necessary to acquire and understand these new practices.

## **LIVESTOCK RESOURCES**

The herding of short-cycle livestock such as sheep, pigs, goats and chickens is expanding in countries in southern Africa—and particularly around the towns—to keep pace with new demands for animal protein and meet the demands of consumers whose tastes are evolving as their lifestyle changes. Some of the production and marketing channels that have sprung up spontaneously need to be rationalized and improved.

### **Supplying N'Djamena with Dairy Products**

Research performed by CIRAD in the context of a regional project in Chad, Niger and Cameroon on small ruminants led to an interest in cheese production and milk product supplies to N'Djamena.

Although these contain very few pathogenic microorganisms, goat milk cheeses produced on-site



were of inconsistent quality due to the instability of vat deposits, which contain the microorganisms that give cheese its taste and smell. Vast amounts of curdled milk were lost because of this phenomenon. French expertise in cheese-making, adapted to the country's conditions, made it possible to develop methods for conserving the deposits. The entire goat's milk cheese production will be sold in N'Djamena, contributing to the resources of the capital's periurban herders.

In addition, biochemical markers analysed in various goat breeds in the Sahel showed a much higher proportion of wild alleles in the casein-alpha3 locus than in French varieties. Selection of the latter because of higher milk yield helped eradicate certain variants of casein-alpha3 which contribute to milk coagulation. This discovery illustrates the importance of biodiversity studies in Southern countries.

Each year Chad imports 1,500 t of powdered milk, equivalent to 8,000 t of reconstituted milk, half of which is consumed in N'Djamena. A study of the production and marketing of dairy products around the city was undertaken to identify weak links in the chain and reinforce them.

Surveys revealed that the 1,300 t of milk products delivered annually to N'Djamena are made

up of 1,000 t of curdled milk, 100 t of fresh milk and 200 t of butter. Cows' milk comprises 90% of this periurban production.

Milk collecting functions relatively well, even though this is organized on an informal basis. The milk takes 1 or 2 days to get to the city—it is collected within a radius of 100 km—which explains the preponderance of more stable curdled milk.

The supply chain will now be analysed from the producer to the consumer.

### **Periurban Goat Herding**

CIRAD is coordinating a socioeconomic study on periurban sheep herding which was launched in January 1994. The programme, called "Sécoville", is financed by the European Commission and

brings together research institutions from five African countries—CIRDES in Burkina, IRZV in Cameroon, Institut des savanes in Côte d'Ivoire, the Ministry of Rural Development in Guinea and the Bénin University in Togo—and four from European countries—GTZ in Germany, Prince Léopold University in Belgium, CIRAD in France and Thessalonika University in Greece.

Africa is experiencing increasing urbanization and with it, at the heart and on the outskirts of the cities, a new and uncontrolled increase in sheep herding. This is hardly adapted to urban environmental and sanitary requirements and will be unable to meet the growing needs of an expanding market in animal proteins unless something is done quickly.

## INTERNATIONAL MEETING

### **Camel Milk Production**

*The second meeting of the CIRAD coordinating unit for camel breeding was held in Nouakchott (Mauritania) on 24 to 26 October 1994. The debates centred on milk production from large camel breeds (dromedaries and camels), and from breeding practices to dairy products. This traditional source of protein for herders could be used to meet the demands of urban populations in arid and semiarid zones, as is the case in Mauritania and Saudi Arabia, where periurban herding is developing. The participants also requested a survey of the potential market for their milk products.*

*At this meeting, a series of reference values for camel pituitary hormones (luteinizing hormone, follicle-stimulating hormone or FSH, growth hormone and prolactin) were presented by CIRAD after work it had conducted in collaboration with INRA. The comparison of hormone levels in biological samples with reference values will now provide useful information concerning camel reproduction and lactation.*



The Sécoville programme will define the criteria necessary for change and propose a system enabling periurban herders to continue to operate in harmony with urban life and to increase their standards of living while complying with urban antipollution measures. Consumer demand and its expansion will be analysed by economic and sociological surveys, while livestock-production research should select high-quality and productive animals to keep pace with rising market demand. The environmental consequences of periurban breeding will be studied to map zones where it can develop and where it should be curbed.

## LIVESTOCK PRODUCTION SYSTEMS

In tropical countries the herding of small ruminants occupies a very important place in the family economy. Development of this activity is hindered by the poor health of the herds. CIRAD and its Southern partners have undertaken to study small ruminant production systems in real situations, with a special aim

to analyse the complex relations between pathology and productivity. This approach to animal pathology primarily provided a technical diagnosis of the way the systems function. Research and development then focused on the most relevant objectives: improvement of the sanitary conditions in Senegal and Cameroon, and organization of the industry in Zimbabwe.

### Follow-up of a Herd in Northern Cameroon

In northern Cameroon, 65 herders were followed up on a livestock-production and health basis by CIRAD and IRZV, and their animals given trial supplements of cottonseed cake at the end of the dry season. There were 4,500 sheep and 4,000 goats among some 12,000 animals observed. The data collected were processed using CIRAD's Pikbeu software to define the main livestock-production parameters of small ruminants.

Sheep first give birth at 18 months, and goats at 16 months. At birth, a lamb weighs 2.6 kg on average, a kid, 1.8 kg. The growth of kids slows down considerably after the 4th month, which corresponds to weaning, whereas lambs seem not to be affected.

### PUBLICATION

#### A Manual of Tropical Ecopathology

*Ecopathology was developed to find valid economic solutions to problems arising from multi-factor pathology in intensive production in industrialized countries.*

*Today it is being applied to the radically different context of extensive herding in the hot regions of the world. In Ecopathologie animale, méthodologie, applications en milieu tropical, CIRAD and INRA researchers discuss the methods involved in this research then cite studies conducted in Brazil, India, Senegal, Chad and Zimbabwe to describe current practices used in ecopathological surveys in tropical countries. It is co-published by CIRAD and INRA and serves as a reference guide and tool for epidemiologists who want to undertake ecopathological research in the South.*

Breeders recognize that cottonseed cake as a feed supplement is beneficial to their herds, but when, in 1994, its price trebled during a particularly difficult period, it became clear that cottonseed cake is a luxury to be fed to nursing mothers or recently weaned young, and that other sources of feed supplement, such as fodder crops, had to be developed.

The main cause of death among lambs and kids is infectious

disease. Pulmonary infectious diseases predominate, so clinical and serological follow-up was initiated in several herds. In 50% of fatal cases, the peste des petits ruminants is associated with smallpox virus. A mixed vaccine has been developed and tested by the Laboratoire national vétérinaire in Cameroon and is soon to be distributed for field use.

### **Goat Production in Zimbabwe**

Most herders in rural zones of Zimbabwe possess goats, but the revenue from these small ruminants accounts for only 1 to 20% of gross agricultural product. Despite the fact that the production system is increasingly money-based, the goat herd has maintained its traditional social and cultural role in the region.

In this light, herders are reluctant to invest time and money in improving herd productivity, preferring to content themselves with stabilizing herd numbers. The lack of any organized marketing chain which would permit them to recoup on investment contributes to their indifference. The absence of producer to consumer and rural to urban outlets is explained by several factors: in this rural society, exchange takes place traditionally within the extended family; people live far apart and, until

recently, beef produced by large commercial firms was subsidized by the government.

The harsh drought in 1992, which caused the death of 80% of the cattle in some villages, followed by structural adjustment and the withdrawal of beef subsidies, have considerably altered the economy and people's behaviour. Producers and consumers alike are taking an interest in goat meat and ways of organizing market channels. CIRAD and local agencies have begun to inventory and assess production potential. Production and consumer zones are being defined, herds are being inventoried, herders are being classified, and land management schemes proposed. Ways of organizing production channels are under study with the creation of local markets, product presentation to marketing intermediaries, technician training, and herder education.

### **Ecopathology in Small Ruminants in Senegal**

CIRAD and ISRA have been studying traditional herding of small ruminants in Senegal for more than 10 years. Individual data have been collected on some 7,000 sheep and goats belonging to 300 herders, along with supplementary data on herding practices. These data have been

organized, validated and preprocessed using CIRAD's Panurge database, which has simplified the calculation of the main livestock-production parameters.

Herd productivity is considerably reduced by lung diseases. Improvements in the traditional shelters would help in controlling these diseases.

Parasite infestation studies conducted over 2 years with ILCA revealed a predominance of *Haemonchus* and *Trychostrongylus* strongyls found in the digestive tract. Individual values for infestation markers—the number of eggs per gram of faeces, hematocrit—vary greatly, with transmission from the mother being particularly significant at the end of the rainy season. The study contributed to the assessment and improvement of parasite infestation measuring methods. INRA and CIRDES will be associated in a further study on genetic resistance to gastrointestinal strongyls in small ruminants.

### **Evolution of Production Systems in the Sahel**

A comparison of the production systems in the Sahel zones over 4 years revealed that the quality of the rainy season—how much rain and where—remains

## NETWORKS

### Scientific and Methodological Exchanges on Herding Systems

A European group on herding systems has been set up at the initiative of CIRAD and INRA. It aims to promote scientific and methodological exchanges between research and development on the one hand, and conventional livestock-producers and researchers studying herding systems on the other. The interest it has aroused has given birth to an international symposium, to be held every 2 years in association with the *Fédération européenne de zootechnie (FEZ)*. It first met in Toulouse, France, in 1990, then in Saragossa, Spain, in 1992 and in Aberdeen, United Kingdom, in 1994. The herding systems group might well be given permanent working group status within FEZ in the near future.

primordial in this system. In years of drought, most families survive thanks to some form of expatriate revenue. The herds, which are decimated during the years of poor cropping, are reconstructed as soon as plants grow again.

Although a classification of production systems established using technical criteria is of considerable use to development project directors, the family's

nonagricultural activities and agricultural policy measures, which sometimes lead producers to change strategies, also need to be taken into consideration.

## AQUACULTURE AND FISHING

The tilapia figures among the world's main fishfarming species, since it is highly adaptable to all breeding systems. As CIRAD seeks to improve breeding of the species, it must reply to an incredible variety of questions taking into account the diversity of enquirers' situations.

### Ecology of Fishfarming Ponds in Côte d'Ivoire

Over the past few years in Côte d'Ivoire, fishfarming in ponds has developed mainly near cities, in rehabilitated lowlands close to irrigated cropping areas, where water, inputs and viable markets are to be found. But in rural zones far from urban markets, pond productivity remains low. Fishfarmers find it difficult to obtain supplies for fertilizing the ponds and feeding the fish. Production is limited by trophic factors: below a certain level, fertilization

is ineffective and the growth of the tilapia, *Oreochromis niloticus*, ceases abruptly and inexplicably between 200 and 250 g, which decreases their market value.

CIRAD and IDESSA decided to study the trophic network of the ponds, beginning with their physico-chemical and biological characteristics, in an attempt to remove these obstacles. About 40 samples were taken in the dry and rainy seasons. Conductivity of the water analysed was less than 100 microsiemens/cm, as compared with 400 to 500 in the well fertilized periurban ponds, and it contained few nutritive elements (less than 0.5 mg/L of phosphate and less than 1 mg/L of total mineral nitrogen). Some of the ponds were rich in iron—up to 13.7 mg/L. Although iron is not biotoxic since few ferrous ions are present, it can fix certain nutrients and impede restitution of those contained in the subsoil. How the fish use this poor environment has yet to be understood. The aim is to develop a fishfarming system needing few inputs and therefore adapted to the socioeconomic conditions of these rural zones.

### Biology of the Red Tilapia in Réunion

A programme to encourage production of the Gueule rouge, a tilapia hybrid, was launched by the Association réunionnaise pour



## INTERNATIONAL MEETING

**Farming Siluroid Fish**

*Almost 150 scientists from all over the world attended "Basil 94", the first international workshop on the biological bases of siluroid fishfarming, held in Montpellier in May, 1994. It was organized by GAMET (Groupe aquaculture continentale méditerranéenne et tropicale), which brings together researchers from CEMAGREFF, CIRAD and ORSTOM, and thus provides an overview of knowledge concerning the biology of the catfish, its breeding systems, processing and marketing. The 250,000 t of catfish produced every year represent only 3% of world fish production. But in Thailand the recent and spectacular increase in catfish production and the economic importance of this industry in the USA indicate that catfish farming has a promising future, provided that the species used are chosen to meet consumer demands.*

le développement de l'aquaculture (ARDA) with support from the region. Only the male of this species is economically viable, and a major obstacle to breeding is the necessity to find a way of breeding males without having recourse to artificial hormones, which are forbidden. ARDA asked CIRAD and INRA to conduct research prior to setting up private operators in this field. The first results were obtained in 1994.

Hormone inversion was the first option explored in the search for all-male tilapias. The natural hormone identified in the testicles of *Oreochromis niloticus*, 11 beta-hydroxyandrostenedione, is equivalent to the artificial hormone usually administered, 17 alpha-methyltestosterone. Administered to Gueule rouge fry as a 50 mg/g dose of feed over a period of 28 days, this resulted in an all-male population. The treatment costs 4 centimes per fry, which is negligible compared with the sale price of the fish (47 francs/kg, or 14 francs for a 300-g fish).

The second study option was to investigate the influence of environmental factors on sex determinism. Temperature, for example, influences sexual differentiation of the red tilapia. This is the first time such a mechanism has been

observed in a tilapia hybrid, and opens the way to the possibility of producing monosex male populations without damage to human health or the environment.

Genetic manipulation also aims to obtain progenitors producing all-male progeny. A study of genetic sex determinism was a preliminary necessity.

It has been proved by the analysis of mitochondrial DNA polymorphism that the Gueule rouge is a hybrid produced from numerous and successive crossings of four tilapia species: *Oreochromis niloticus*, *O. mossambicus*, *O. hornorum* and *O. aureus*. The four types of sex ratio observed in the 39 hatchings obtained from crossing 6 males and 22 females chosen according to their colour phenotype seem to show that all the sex chromosomes of the four species have been retained. In the two male genotypes identified, YZ and ZX, the presence of Y and Z chromosomes suggests that genetic crosses should make it possible to obtain YY or ZZ progenitors, producing all-male progeny.

## INFECTIOUS AND PARASITIC DISEASES

Livestock diseases, whether of infectious or parasitic origin, are still the main obstacles to the development of livestock herding in the tropics. Numerous partners from the North and South have been asked by CIRAD to cooperate whenever possible in the work it carries out.



## Epidemiology of Rinderpest and Peste des Petits Ruminants

After 10 years of research, veterinary doctors now have at their disposal several vaccines and diagnostic tests for rinderpest and peste des petits ruminants. A test is still under trial at the CIRAD laboratory of tropical animal pathology. It is a two-step competitive ELISA which can detect and differentiate between the antibodies produced against rinderpest and the peste des petits ruminants, in the same sample. The presence in cattle of the peste des petits ruminants virus induces an asymptomatic immune reaction which protects the cattle from rinderpest. This test would provide a more precise assessment of the efficacy of vaccination campaigns against rinderpest.

Now that the means of fighting these two diseases have been developed, scientists are studying their epidemiology to determine their origins. Such a programme, financed by the European Commission, was launched in 1994. CIRAD, as project coordinator, has been joined by five other research institutes: in the South, the Laboratoire national d'appui au développement agricole in Côte d'Ivoire, the veterinary services of Guinée-Bissau, the Indian Institute of Science in India; in the North,

the Pirbright laboratory in the United Kingdom and Lisbon University in Portugal. It aims to collate data on the gene sequences in the different strains of the two diseases collected in the field. This data bank would serve to identify any virus discovered in an epidemic. Wildlife will also be studied to determine whether they are host to the peste des petits ruminants virus.

Preliminary results have shown that the peste des petits ruminants virus is not always the same. A virus taken from Asian samples was isolated by CIRAD. Analysis by PCR (polymerase chain reaction) and gene sequencing of one of the proteins showed that it was different from African or Middle Eastern strains.

## Control of Mycoplasmoses

A method has been developed for selecting monoclonal antibodies directed against mycoplasma antigens. This has led to a study of the specificity of monoclonal antibodies directed against *Mycoplasma capricolum* subsp. *capripneumoniae* (MccF38), the agent responsible for contagious caprine pleuropneumonia, formerly known as *Mycoplasma* sp. type F38.

One of these antibodies is used in a blocking ELISA test, which presents many advantages compared with the current

reference test, i.e. the complement fixation reaction. The test is very specific as there is no cross reaction with antibodies directed against mycoplasmas very similar to MccF38, but which induce other diseases. It is also more sensitive. More precise data concerning the spread of the disease and its economic repercussions can now be collected.

Lastly, several MccF38 genes have been sequenced and polymerase chain reactions specific to this mycoplasma have been obtained. This leads the way to gene expression in vectors and production of large quantities of the antigen for vaccines. The sequencing of genes which apparently vary from one strain to another might be the origin of molecular epidemiology of mycoplasmas of the *mycoides* group. All the species in this group are pathogenic in ruminants.

Contagious bovine pleuropneumonia, a pulmonary and pleural infection, is one of the most serious diseases caused by bacteria in this group. In October 1994, a new project, financed by the European Commission, was begun to carry out research on this mycoplasmosis. It is piloted by CIRAD in collaboration with national veterinary laboratories in Cameroon, Ethiopia,

## TRAINING

**Rapid Diagnosis of Mycoplasmosis**

*A training course into methods for rapidly diagnosing mycoplasmoses in ruminants was organized at Maisons-Alfort from 17 to 25 November by Pathotrop, the tropical animal pathology laboratory of CIRAD, with support from FAO. Eight researchers from Africa and the Middle East were introduced to molecular biology techniques: DNA amplification in vitro by polymerase chain reaction and use of monoclonal antibodies.*

Kenya, Namibia, Uganda, Portugal, the universities of Munich (Germany), Rennes (France), Uppsala (Sweden), and the Zooprophyllactic Institute of Teramo (Italy).

One of the aims of the project is to develop a vaccine to protect bovines for longer than today's vaccine, whose efficacy wanes after 18 months. The new vaccine would use a part of the membrane instead of the whole bacteria. To assist in its development, the immune reaction in the cattle will also be studied to determine whether this is humoral (producing antibodies which neutralize the antigen) or cellular (directly attacking the antigen via the lymphocytes). This project will enable CIRAD to assess its diagnostic techniques on a large scale in the field.

**Trypanosomiasis: a New Channel to Explore**

CIRAD is collaborating with CIRDES (Burkina) and ILRI (Kenya) in research on trypanosomiasis and its vectors. In 1994, researchers identified a proteolytic enzyme in *Trypanosoma congolense* which might be responsible for certain pathogenic mechanisms. Trypanotolerant African cattle have a stronger immune response to this enzyme than sensitive bovines. Production of recombinant fragments of this enzyme by genetic manipulation could contribute to the control of this disease. It would be an interesting channel to explore in the absence of any conventional vaccine against trypanosomiasis.

## THESES COMPLETED IN 1994

## CIRAD Scientists

**Les pneumopathies des petits ruminants au Sénégal : étude séro-épidémiologique et biogéographique** [Pneumopathology in small ruminants in Senegal: sero-epidemiological and biogeographical study] by Denise Lefèvre-Desoutter, Université Paris XII.

**La pleuropneumonie contagieuse caprine : de l'observation clinique à la mise au point de techniques de diagnostic** [Contagious caprine pleuropneumonia, from clinical observation to development of diagnostic techniques] by François Thiaucourt, Université Paris XII.

## CIRAD Trainees

**La lutte contre la peste bovine en Côte d'Ivoire : coûts et bénéfices des campagnes de prophylaxie ; problèmes posés pour son éradication** [The control of rinderpest in Côte d'Ivoire: costs and benefits of the prophylaxis campaign; problems encountered in its eradication] by Emmanuel Couacy-Hymann (Côte d'Ivoire), Université Paris XII.

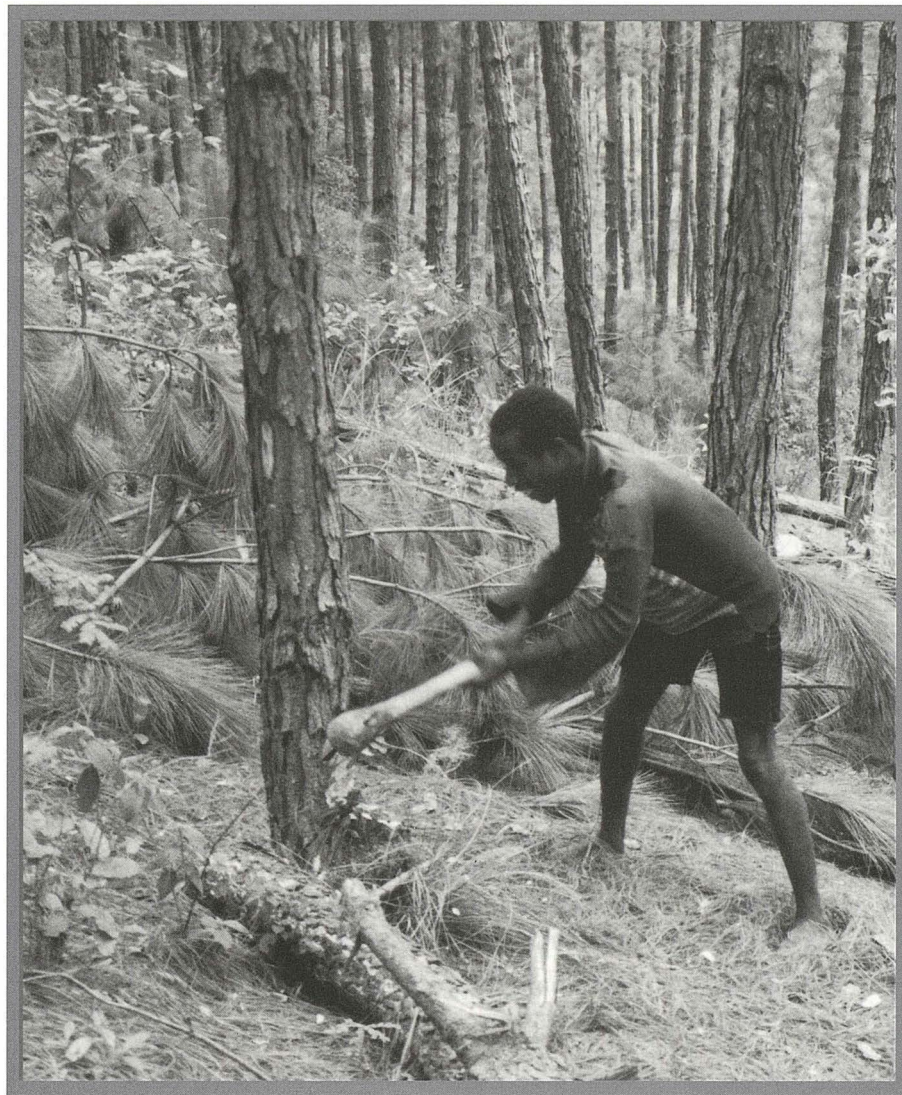
**Contribution à l'étude des tiques (*Acarina, Ixodoidea*) et des hématoparasites du bétail au Sénégal** [Contribution to the study of ticks (*Acarina, Ixodoidea*) and hemoparasites in Senegalese livestock] by Arona Gueye (Senegal), Université Paris XI.

**Recherche de polymorphisme génétique chez les caprins : application à l'étude de la diversité des populations, au contrôle de filiation et à la résistance génétique à la cowdriose** [Studies on genetic polymorphism in goats: application to the study of population diversification, breeding control and genetic resistance to cowdriosis] by Laurent Pépin (France), Université Paris XI.

A photograph of a person, likely a forester or logger, working in a forest. The person is shirtless and wearing dark pants, leaning over a log on the ground. The forest is dense with tall, thin trees and undergrowth. The text "Forestry Department" is overlaid in a large, black, serif font in the center of the image.

# Forestry Department





**I**n 1994, following a period of international environmental awareness, highlighted by the Earth Summit (Rio de Janeiro, 1992) and creation of the Center for International Forestry Research (CIFOR), discussions and planning focused closely on specific means of implementing the proposed guidelines. Sustainable forest management was in the forefront of these debates that touched on a wide range of topics.

A legislative initiative on forests is also in preparation following a European Parliament study on developing a global community strategy in the forestry sector.



*There is a common will to move from political thinking to actual project proposals. Thus certain ideas have to be fully defined. It was suggested, after some Northern countries voiced their intention to boycott tropical woods, that wood sourcing from well-managed forests should be given an ecolabel. This was developed further by the ecocertification concept, which would be used to address the problem of the quality of forest management. New integrated forestry management programmes have been launched in western and central Africa. This is evidence of a vital movement to develop well-adapted management techniques for sustainable tropical forest management through collaborative involvement of ministries, users and research scientists.*

*CIRAD-Forêt is more than ever dedicated to conducting scientific research to fuel the debate on the future of tropical forests. This objective was again pursued this year through studies on natural forests and silviculture, in dry and wet regions of Africa, Asia and America, and by analysing the socioeconomic conditions required for rational use of rain forests.*

*A regional project to promote the efficient application of research findings to forest ecosystems in humid parts of Africa was prepared in 1994. This will provide an opportunity, in 1995, to review the research results on natural forests and silviculture. New sustained forest management proposals based on the technical outcome of these projects will thus be possible.*

*Also in 1994, the Department's research programme on wood was moved to Montpellier, thus paving the way to new cooperative activities.*



## NATURAL FORESTS

Although natural forests are vital for the ecological balance in tropical countries and over the entire globe the management of these resources can be effective only through involvement of all people concerned, providing for their needs and with their participation.

## Rain Forest Management

At the outset of the 1980s, there were still more than 1 million ha of dense rain forests in southern Guinea. By the most optimistic estimates, only 600,000 ha were left by 1989. The two largest reserved forests of Ziama (100,000 ha) and Diecke (60,000 ha) still have primary stands with an exceptional biodiversity of western African flora and fauna.

## FORESTRY DEPARTMENT

### CIRAD-Forêt

Director  
*Jean-Marc Dubois*  
 Research Director  
*Jean-Claude Bergonzini*  
 Programmes Director  
*Jean-Louis Muron*  
 Administrative and Fiscal Director  
*Claude Thevin*

### Research Programmes

Natural forests  
*Henri-Félix Maitre*  
 Forest plantations  
*Philippe Vigneron*  
 Agroforestry  
*Bernard Mallet*  
 Wood  
*Bernard Thibaut*

### Research Units

Silviculture and forest management  
*Jean-Pierre Bouillet, Jean-Guy Bertault*  
 Diversity and genetic improvement  
*Hélène Joly*  
 Soil typology and land use  
*Yves Prin*  
 Resource analysis  
*Bernard Thibaut*  
 Wood processing  
*Louis Vergnet*  
 Economics  
*Jean-Louis Muron*  
 Biometrics  
*Jean-Claude Bergonzini*

### Support Services

Documentation  
*Lucien Trong*  
 Publications  
*France Lavaux*  
 Training  
*Hélène Laforge*  
 Consultancy and operations bureau  
*Jean Estève, Mireille Chiaverini*

### Joint CIRAD-ORSTOM Unit

Biotechnology of  
 tropical forest symbioses  
*Emile Duhoux*

The urgent need to quickly halt deforestation and protect this forest heritage prompted the World Bank and the German Kreditanstalt für Wiederaufbau (KfW) to jointly fund a forestry resources management project (Progerfor) for these two forests. This project, conducted from 1990 to 1994, was founded by CIRAD and Deutsch Forst Consult (DFC) in conjunction with the Guinean forestry administration. It will be implemented in 1995 within the framework of a general Guinean natural resources management project.

According to the management objectives, the different parts of the forests were classified under three different categories: totally protected zones (36% of the forested area at Ziama, 25% at Diecke); sustainable use zones, i.e. limited areas utilized by nearby villages (41% at Ziama, 33% at Diecke); and improvement zones to re-establish the resource (23% at Ziama, 42% at Diecke). From 1991 to 1994, more than 1,000 ha were reforested with several different species, including *Terminalia superba*, *T. ivorensis* and *Cedrela odorata*.

The vital needs and interests of local inhabitants are a critical parameter of this project. For instance, in the sustainable use zones, the inhabitants of nearby villages have certain users' rights such as harvesting fruit and other

nonwood products, rice cropping in the lowlands and hunting. In addition, local labour is used for the reforestation work, and it is estimated that one permanent annual job position is created for every 2 ha planted. Local inhabitants are included in future forest management plans, to survey their own forest heritage and draw benefits from this resource.

### Natural Forest Use and Conservation

The Central African Republic is one of the six countries involved in the programme for the conservation and wise use of forest ecosystems in central Africa (Ecofac), which is funded by the European Commission. In that country, CIRAD is conducting a project in the 60,000 ha N'Gotto forest in the southern part of the country. Part of the forest is totally protected, another is set aside for agricultural development, and another (30,000 ha) is the site of a pilot forest management project.

The processing of inventory data and remote sensing have been able to quantify and localize exploitable species—namely sapele (*Entandrophragma cylindricum*). Stand dynamics have also been studied in an experimental plot that was set up in 1982 in the natural forest of M'Baiki. The results were used to draw up, for the first time, a forest-use plan corresponding to

### INTERNATIONAL MEETING

#### International Workshop on Sandalwood

*There is renewed interest in the aromatic wood of the rare sandalwood (Santalum sp.) tree. An international workshop, organized by CIRAD and the South Pacific Forest Development Programme (SPFDP) and funded by many sponsors, was held in New Caledonia from 1 to 11 August 1994. It brought together specialists from the entire Pacific region. The focus of this workshop was both scientific and practical, with foresters from six countries pooling their knowledge for informative exchanges in the fields of biology, propagation, silvicultural techniques and sandalwood uses. Cooperation between the regional countries was organized under the aegis of the forestry development programme of the United Nations Development Programme (UNDP). These meetings provided a dynamic new outlook for traditional sandalwood plantation owners and the forestry service of New Caledonia.*

the specific output of this forest; this will ensure the sustainability of the exploited species.

Sustainable use of this forest is based on two main options, a 40-year waiting period between each logging, and modified conditions for obtaining a logging licence. The latter was formerly granted for the lifetime of the

logging company, whereas now the company will be initially allowed to log the forest for only 5 years and then, if the company has fully complied with the regulations, the licence can be renewed.

### The Vegetation of Sudanian Africa

With the impoverishment of vegetation in the Sahel, local inhabitants will likely be increasingly obliged to obtain from the Sudanian zone replacement resources, e.g. wood and other products such as fodder and medicinal plants. However, little is known about Sudanian vegetation.

The woody plants of Mali were inventoried from 1985 to 1991. A detailed study of the Mandingo mountains, considered as a representative sample, was undertaken; this resulted in the first taxonomic and population dynamics description of Sudanian vegetation. It was found that three main taxonomic orders make up 95% of the vegetation: one order with *Combretum glutinosum* (index species), climatic climax from "dry" environments; and two orders from relatively humid environments.

A population dynamics analysis of this vegetation revealed a clear regression due to the combined effects of recent drought, human pressure and livestock grazing. The original vegetation is disappearing

completely in the northernmost areas. On the other hand, the situation is not as serious further south since there are still sufficient water supplies, but the outmigration of northern people is seriously upsetting the natural balance there.

## FOREST PLANTATIONS

The international community's insistency on environmental protection has shed fresh light on the importance of forest plantations, which are being tapped to an increasing extent to meet substantial worldwide needs for wood. All activities associated with these plantations have thus been pooled into a single programme. The improvement of some tree species is one important research focus of this programme. The following three examples highlight how the programme addresses a wide range of different situations, from village to industrial plantations, and from quick-growing to timber species.

### Forest Tree Seed for Malagasy Farmers

In Madagascar, the city of Antananarivo alone consumes

1 million m<sup>3</sup> of wood yearly, equivalent to the production of an 80,000 ha planted forest. Smallholders provide much of this production from wooded plots of less than 1 ha. There is a considerable need for improved plant material. Improved varieties can be distributed on a large-scale to rural communities only as forest tree seed.

A national programme was launched in 1993 by CIRAD and the Centre national de la recherche appliquée au développement rural (FOFIFA). This programme is funded by the European Development Fund (EDF), to create seed orchards, thus promoting the future of forestry in Madagascar. Orchards are set up at two separate sites in each of the four climatic zones of the country. Twenty-six orchards, corresponding to half the number planned by the programme, had thus been created by late 1994 (capable of producing enough seed to plant 50,000 ha/annum); seed harvests will begin in 1997. Twenty different species were chosen, mainly eucalyptus and acacia species, based on research collected over the past 20 years. Fast-growing, multipurpose species capable of adapting to a variety of environments were favoured. For each species, trees from many different origins were planted at high densities, followed by



## PRODUCTS FOR DEVELOPMENT

### Cloning Teak

*Teak, Tectona grandis, is a forest species which produces a precious wood that is widely used in furniture and boat building. Teak from natural forests is often of poor market quality, and there are only about 2–3 million ha of teak plantations worldwide. The market demand, which is around 3.5 million m<sup>3</sup>/annum, is still far from being met. Many high-quality teak saplings are thus required for reforestation and plantation development.*

*Teak stands usually contain very few perfect trees, which means that many traits have to be taken into consideration for genetic improvement. Vegetative propagation of the best trees is therefore a good strategy. However, until now this technique has been hindered by the problem of rejuvenating teak cuttings sufficiently to assure normal growth.*

*In Malaysia, CIRAD, in collaboration with Innoprise Corporation, has just perfected a clonal propagation technique to produce rejuvenated cuttings. The teak resource is being "tapped" by cutting pieces of branches from selected teak trees and forcing them in a nursery until shoots are produced. These shoots are taken as cuttings (parent stock), which in turn produce suckers for further cuttings. Rejuvenated cuttings are thus obtained after the second propagation by the parent stock management technique. There is an 80% success rate under semi-industrial conditions, indicating a promising future for teak clonal plantations.*

an intensive selection process involving successive thinning. The ideal traits were considered to be hardiness, plasticity, early growth and vigour.

This programme will help in meeting the wood needs of a fast-growing population and improve the standard of living of smallholders and traders involved in the wood sector.

### Facilitating Controlled Eucalyptus Pollination

A eucalyptus mother tree is always recognized since it bears the seeds that are collected, but the

paternal parent is more difficult to determine. In genetic improvement programmes, controlled pollination can be used to create families in which all of the members have the same parents. Moreover, by the same technique, factors responsible for variance in tree populations can be investigated to optimize selection programmes. In French Guiana, studies are under way to improve controlled pollination techniques that were developed about 20 years ago and used on a large scale since then. There are two elements that complicate and slow down the work of the pollinator, i.e. the problem of

reaching the flowers in the mother trees and irregular flowering.

Many replications of the same genotype can be obtained by grafting branches from selected parent trees. A grafting technique was perfected for *Eucalyptus urophylla*, *E. grandis* and *E. pellita*. About 1,600 grafts from 94 different clones were thus performed with a high success rate (60–70%). A technique was also developed to espalier grafted trees so that the flowers are within reach of the operator. Out of the 800 trees grafted and trained on espaliers in 1993 and 1994, 27% had already flowered within 1–2 years. By this dual grafting and training technique, seed orchards were created with early, abundant and accessible flowering.

Experiments using growth retardants were carried out to further improve flowering earliness and abundance. The techniques were also used for producing artificial hybrids, the first of which will be planted in French Guiana in 1995, and others will soon be introduced in the Congo.



## AGROFORESTRY

The Agroforestry programme is structured around three main topics: upgrading of agricultural



soil fertility through improved fallowing; permanent tree/crop associations; and the use of trees in land management schemes. CIRAD-Forêt projects to reclaim degraded lands are presented here to highlight the overall involvement of the programme in the environmental protection of inhabited areas.

### Small Forests and Farming Communities in Guinea

Fouta Djallon is a region in northern Guinea with marked topography. On the southern side, there are 19 small forest reserves in which local inhabitants have made clearings for cultivation and livestock farming. Guinean officials aim to reclaim and protect these forests while addressing the needs of people from the local villages. About 55,000 ha are to be preserved, a third being forestry stands and the rest savanna and fallow land.

Conventional forest management would probably be inappropriate in this case because of the human factor and the limited resources of the Guinean forestry service. CIRAD-Forêt (project coordinator), backed by the French Fonds d'aide et de coopération (FAC), has thus come up with a plan to address this specific situation.

For each forest, a vegetation map was drawn up from aerial

photographs and field checks, as well as a map of human activities such as cropping, livestock grazing, burning, gathering of fuelwood and other products, and hunting. Analysis of these two superimposed maps and foresters' discussions with local inhabitants helped in defining the type of interventions required to protect the forests and regenerate the degraded areas. An operational plan was sketched out for each forest. Users' rights are clearly set out in this plan: food cropping in the lowlands; livestock grazing in accordance with regulations designed to promote forest regeneration; and gathering of various products. The forest boundaries were also reset in agreement with the local villages. Further silvicultural activities are also planned for some of the forests.

The inhabitants were instrumental in drawing up these plans and thus view the objectives quite positively. The method adopted in the present project, which the forestry services were trained to implement, could be used in other regions where farming communities have a strong impact on forests.

### Treed Pasture for Livestock

Some 120,000 cattle and deer are being raised on about 1,000 large ranches along the west coast of New Caledonia. They feed on

grasses and two species of shrubs, *Leucaena* sp. and *Acacia farnesiana*, in natural and artificial rangelands. However, the first of these species is heavily infested with psyllids and the latter is very thorny. Feed shortages are common during periods of drought.

Shrub species with high forage productivity, palatability and environmental adaptability were assessed jointly by CIRAD-Forêt and CIRAD-EMVT in multilocation trials, and tested with livestock herders. Two leguminous species that can grow as high as 2 m within 2 years are of particular interest: *Acacia ampliceps* produces 2 t/ha dry matter over this period and adapts well to the driest areas; *Calliandra calothyrsus* produces 5 t/ha dry matter in areas where precipitation is above 1,000 mm/annum.

These species, in addition to their forage potential (of particular interest for deer which require woody fibre in their diet), will be useful for erosion control.

### Restoration of Mining Sites in New Caledonia

New Caledonia is the world's third-ranking nickel producer, with an extraction output of 3–4 million t/annum. The nickel ore deposit is concentrated at the base of a decayed rock mantle about 30 m

thick, which means that almost 10 million t/annum of sterile material is excavated. This has given rise to a vast 20,000 ha area of barren material, often toxic to plants, which is subject to heavy erosion that pollutes nearby rivers and streams. The natural revegetation process is very slow and still incomplete after several decades. The damage is substantially reduced with improved mining techniques, and the mining companies now set aside part of their budgets to restore these degraded zones.

In the framework of its research management mandate assigned by New Caledonia, CIRAD-Forêt, in collaboration with ORSTOM and the French Muséum national d'histoire naturelle, is working on upgrading this environment by restoring a vegetation cover. The studies are focused on New Caledonian pioneer plant species (i.e. the first plants to colonize a bare area), since previous tests carried out in the 1980s with introduced varieties were unsuccessful. *Casuarina collina* (ironwood) and *Acacia spirorbis* (gaïac) grow particularly well on mine excavation soils.

Other ligneous and herbaceous species of the indigenous flora are being screened for potential associations with the pioneer species; the ultimate aim is to reconstruct a full multistratum

ecosystem at these replanting sites. CIRAD-Forêt supplies seed to private nurseries which, in turn, carry out the planting operations. Neighbouring countries with similar problems are now showing an interest in this research.



## WOOD

It is becoming increasingly evident that a wide variety of tree species should be felled from natural forests for efficient sustainable management. The properties of these species have to be fully investigated before they are utilized, since little is known about many of them. Links between genotype, forestry practices and wood quality (in which quality criteria differ according to the ultimate use) should be established for tree species from industrial and smallholder plantations in order to clarify the choices for growers. Tropical wood technology research is, more than ever before, the product of dialogues with foresters.

### Quality of Plantation Eucalyptus Wood

Many tree plantation species, such as eucalyptus, cannot be processed as timber because they develop

## PRODUCTS FOR DEVELOPMENT

### The Wood Industry in Togo

*The action plan to help furniture makers in Togo, which was assigned to CIRAD-Forêt in 1991, is being funded by the United Nations Industrial Development Organization (UNIDO) and the French and German technical assistance agencies. This project aims to determine the reasons behind the failure of companies that were set up to mass-produce teak furniture for export, and then assist them in reaching their goal.*

*Many problems concerning wood drying, varnishing, design, tool sharpening, etc., were discovered. Sessions were thus organized, in 1993 and 1994, to train about 100 salaried staff in 10 furniture manufacturing plants. At this time, trainees were introduced to CIRAD-Forêt's technique for reconstituted wood. In 1994, one company successfully showed its furniture models at the Salon du mobilier de bureau in Paris. Furniture manufactured in Togo will be promoted throughout Europe in 1995 and 1996.*

cracks and other deformations during such operations. These faults are partially due to variations in the physical and chemical characteristics of the wood.

Studies have revealed that genotype, growing conditions and the interaction of these two factors

## PRODUCTS FOR DEVELOPMENT

### Wood Carbonization and Pollution Control

*Charcoal is the main domestic fuel in urban areas of developing countries. It is also used extensively to fuel heavy industries. Unfortunately, standard wood carbonization processes are energy-intensive and produce fumes containing gases that contribute considerably to the greenhouse effect.*

*CIRAD-Forêt, in collaboration with the Laboratoire national d'essais (LNE) and the Centre interprofessionnel technique d'études de la pollution atmosphérique (CITEPA), with funding from the French Ministère de l'environnement, the Agence de l'environnement et de la maîtrise de l'énergie (ADEME) and the Agence nationale de valorisation de la recherche (ANVAR), have developed techniques to measure and determine the compositions of these gases. The most common gases produced are CO, CO<sub>2</sub>, CH<sub>4</sub> and NO<sub>x</sub>. In fact, the equivalent of 8–11 kg of carbon dioxide are emitted into the atmosphere for every kilogramme of charcoal produced.*

*The results of these investigations highlight the necessity for pollution control measures. CIRAD-Forêt first improved incinerators designed to process carbonization fumes, and then modelled the kinetics of fume emission. This should enable industrial manufacturers to optimize their own incinerators.*

*Another considerable advantage is that 50% of the initial energy of the wood is recovered by this fume incineration process. A European Commission-funded project which will enable a Brazilian sawmill to produce 1,500 t of charcoal/annum is thus being assessed by the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), the Falcudade de Ciências Agrárias do Pará (FCAP) and CIRAD-Forêt. This sawmill will be capable of recovering 296 MWh of electricity (as a substitute for diesel oil), as well as enough hot gas to dry 6,000 m<sup>3</sup> of timber/annum.*

*Fume incineration is used to an increasing extent in Europe where pollution laws are becoming stricter.*

Internal variations in the modulus of longitudinal elasticity and in density, two reference properties of wood, can be explained by the loss of juvenility over time and the formation of heart wood. It is important to classify the notion of juvenility into primary juvenility, associated with the age of the pith, and secondary juvenility, associated with the age of the cambium (just under the bark where horizontal growth occurs). Analysis of variations in the properties along the trunk indicate that, at a given cambial age (as estimated by the distance to the pith), juvenile traits are highest in wood closest to the ground.

These results should help in optimizing cutting times and selecting species, hybrids and clones to reduce potential timber-processing problems.

### Wapa Morphology and Quality

Wapa, *Eperua falcata*, accounts for at least 20% of the forestry resource of French Guiana, and it is also abundant in neighbouring countries. The wood of this tree has excellent natural durability and interesting physical and mechanical characteristics. The main drawback is that there are substantial variations in quality, e.g. many trees split when felled, and they continue to crack and deform at each timber-processing step.

have a marked effect on growth strains, thus highlighting the importance of growth stress (mechanical status of the trunk). Growth strain decreases once there is a "loss of vitality", marked by a very slight increase in trunk

diameter. These results, confirmed with other species, indicate interesting possibilities for controlling growth stress by modifying silvicultural techniques according to the ultimate use of the material.



Criteria are being sought for assessing wood quality in standing trees, so that only high quality trees will be felled.

CIRAD-Forêt first tried to determine the relation between tree morphology and wood quality. The intensity of longitudinal growth stress along the trunk surface was chosen as a quality criterion, as determined by measuring permanent longitudinal growth strains (PLGS). Seven hundred PLGS measurements were obtained on 15 trees using a CIRAD-designed sensor. The analysis highlighted a number of interesting points. For each unbalancing factor (e.g. slope), the wapa tree develops three buttresses: one opposite the side towards which the tree is leaning, two others 45° on each side of this central buttress. PLGS levels are highest on these buttresses up to 300 kg/cm<sup>2</sup>. This suggests that the buttresses (despite the support implied in the name) develop on the side opposite the lean to "pull" on the tree. Their positions could thus be used as tree quality indicators.

### Wood in the Bibliothèque Nationale de France

The architect of the Bibliothèque Nationale de France planned to use a great deal of wood in the design of this library. CIRAD-Forêt was assigned all of

the building design studies, the task of choosing wood species, and the responsibility for quality control of the wood after delivery.

Ipé was chosen for the parvis and the exterior stairways (80,000 m<sup>2</sup>); this choice was based on its very good durability, hardness, abundance in forests and low price. Okoumé was used to build the 22,000 adjustable panels that shield the book stacks from the light; it was chosen because it is highly decorative and tests revealed that it could be successfully applied as veneer over aluminium panels. Afzelia and padauk were used in smaller quantities to decorate the reading rooms and amphitheatre. These woods were from Brazil, Gabon and Cameroon.

This is the first time ipé has been used in Europe. CIRAD-Forêt is also carrying out research on potential uses for new tropical woods for another large ongoing French project, Euralille, which involves the construction of shopping centres, business centres and a TGV (high-speed train) station.

### THESES COMPLETED IN 1994

CIRAD Scientists

**La végétation du centre régional d'endémisme soudanien au Mali ; étude de la forêt des monts Mandingues et essai de synthèse**

[Region of endemic Sudanian vegetation in Mali; study of the Mandango mountain forest and a synthesis study] by Robert Nasi, Université Paris XI, Centre d'Orsay.

**Précontraintes de croissance et propriétés mécano-physiques de clones d'eucalyptus (Pointe-Noire, Congo) : hétérogénéités, corrélations et interprétations histologiques** [Growth stresses and mechanical and physical properties of eucalyptus clones (Pointe-Noire, Congo): heterogeneity, correlations and histological interpretations] by Henri Baillères, Université Bordeaux I.

**Contraintes de croissance, variations internes de densité et de module d'élasticité longitudinale, et déformations de sciage chez les eucalyptus de plantation** [Growth stresses, internal variations in the modulus of longitudinal elasticity and density, and sawing deformations in plantation eucalyptus] by Jean Gérard, Université Bordeaux I.

CIRAD Trainees

**Stratégies de régénération de neuf essences commerciales de forêt tropicale (Mayombé, Zaïre)** [Propagation strategies for nine commercial tropical forest tree species (Mayombé, Zaïre)] by Geneviève Pendjé (France), Université Paris VI.

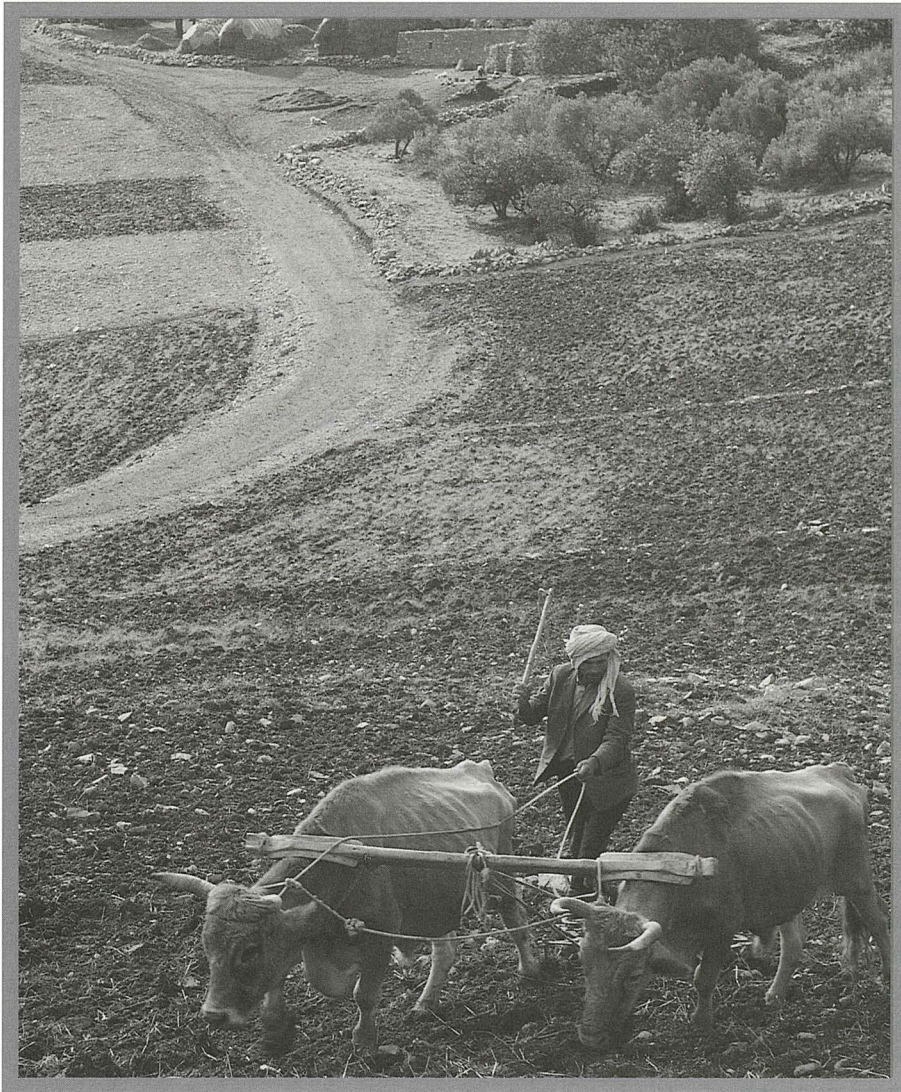
**Gestion des ressources génétiques de *Faidherbia albida* (Del.) Chev. : étude de paramètres de contrôle des flux de gènes intrapopulation** [Genetic resource management for *Faidherbia albida* (Del.) Chev.: study of parameters for controlling intrapopulation gene flow] by Martin Zeh-Nlo (Cameroon), Ecole nationale du génie rural, des eaux et des forêts, Nancy.



The background image is a faded, sepia-toned photograph of a rural landscape. In the foreground, two oxen are harnessed together, pulling a wooden plow. A person is visible behind the oxen, guiding them. In the middle ground, a dirt road or path winds through the landscape. In the background, there are some buildings and trees, suggesting a village or farmstead. The overall scene depicts traditional agricultural practices in a rural setting.

# Food Technology and Rural Systems Department





**R**ural and farming communities are having to adapt to recent directives concerning structural adjustment and the increasing disengagement of governments. In doing so, they are proving their capacity for change and inventiveness. The Food Technology and Rural Systems Department (CIRAD-SAR) can help these communities develop and make better use of local resources, improve their agricultural products and their marketing systems and develop sustainable farming methods. It can also help farmers and farming organizations develop decision-making methods and strategies.

The national agricultural research systems are also having to adapt to the South's economic and social crises. New cooperation programmes will need to integrate the capabilities of CIRAD, these national systems and their member organizations. The Department participates actively in helping to define development research priorities through training and research programming.

The Department in 1994 continued to add to its scientific knowledge in several important fields, e.g. soil fertility management, rural modernization and combined processing of agricultural produce.

## RAINFED AND IRRIGATED FARMING SYSTEMS

It is difficult for individual farmers and management organizations to take decisions in a technically, economically and institutionally unstable environment. Decision-making aids have been formulated to help manage natural and farming resources, irrigation projects and production methods.

### Choice and Management of Field Equipment

For several years, the development of mechanization in tropical regions has been turned over from parastatal agencies to farmer organizations and private contractors. The classic problems of choice and management of equipment are compounded by the complex interrelations between the various actors involved.

A research programme, financed by CIRAD, the Ministère de la coopération and the Caisse française de développement, was set up in 1991 for the irrigated schemes along the Senegal river. CIRAD, ISRA and SAED have been studying the problems faced by farmers and contractors in the management of heavy equipment, such as tractors and combine harvesters.

A decision support system, experimented with farmer organizations cultivating collectively 2,000-ha irrigated schemes with a few contractors, has been transferred to SAED. It includes two softwares: Ridev and Otelo. Ridev, designed in cooperation with WARDA and ORSTOM, is a rice development model which simulates, on several climatic years, cycle duration and sterility rate according to temperature, variety and sowing date. Otelo, designed by INRA, models and simulates work organization on farms. This

## FOOD TECHNOLOGY AND RURAL SYSTEMS DEPARTMENT

### CIRAD-SAR

Director  
*Marc Le Moigne*  
 Deputy Director  
*Vincent Dollé*  
 Research Director  
*Dany Griffon*  
 Administrative and  
 Fiscal Director  
*Serge Oudard*

### Research Programmes

Rainfed and irrigated farming systems  
*Jean-Philippe Tonneau*  
 Sustainable development in the savanna and humid tropical zones  
*Bernard Dolacinski*  
 Promotion of rural output and urban food supply  
*Nicolas Bricas*  
 Local development and institutional dynamics  
*Vincent Dollé*

### Research Units

Agronomy and mechanization  
*Roland Piro*  
 Economics of rural systems  
*Yves Bigot*  
 Socioeconomics of innovations in rural systems and food technology  
*Jean-Michel Yung*  
 Food technology and engineering  
*Anne-Lucie Wack*  
 Software engineering, equipment design, biomass conversion  
*Gilles Vaitilingom*

### Support Services

Documentation  
*Marie-Dominique Lafond*  
 Publications  
*Monique Pellecuer*  
 Training  
*Jean-Luc Mazot*



## PRODUCTS FOR DEVELOPMENT

### Measuring Agricultural Equipment Performance Parameters

*Rational use of agricultural equipment is greatly enhanced by the collection of numerous minutely detailed data in a real environment. An automatic monitoring system is being used in Réunion, Mauritius and Senegal to determine in-field equipment parameters. Where cropping is motorized, sensors installed on the machines measure parameters such as fuel consumption, engine speed, displacement speed, slide and depth, or penetration power. Where farming is still done with animals, sensors measure speed, drag and penetration. SRI in the United Kingdom has brought out a heart rate sensor which functions according to the animal's ear colour to determine tiredness. The sensors are connected to a "black box" where the frequently collected data are stored and managed.*

*Although not yet available, the data concerning motorized farming will constitute a frame of reference for an interactive decision-making aid system developed with INRA. Work is continuing with the Centre français du riz and CEMAGREF on a method to follow up use of the equipment throughout an entire growing season.*

approach is also used on rice-based farms in the Camargue (France), in collaboration with the Centre français du riz, and will be tested in Réunion on sugarcane farming systems with ARMES (Association réunionnaise pour la modernisation de l'économie sucrière).

### Land Management and Rural Development Planning in Madagascar

A third of the paddy rice marketed in Madagascar is produced on the Lake Alaotra plain. For the last few years, the hills surrounding the plain have been eroded at an alarming rate by settlements of migrants and young local farmers, endangering the watershed and, eventually, the plain's rice-growing potential. This uncontrolled land tenancy has resulted in the disappearance of primary forests, more fires, land-tenure confrontations and a general upsurge of insecurity. The Caisse française de développement and Madagascar's Ministère de l'agriculture et du développement rural funded an agricultural land management scheme geared to sustainable agricultural development of the hills. One of the prerequisites to success of any technical intervention is to include the farmers in the project's conception. Six hundred farmers were included in 49 groups.

Eight village communal granaries were constructed to store 200 t of paddy rice and stagger sales. Land ownership has been stabilized through simplified registration procedures drawn up by the Public Domain Directorate. It now takes 9 months—instead of 20 years—to obtain property deeds. This project highlighted the necessity of coherent national policies for farmland management.

### Geographic Information System for the Senegal River Valley

A database has been updated each year since 1990, describing in detail the farmer organizations, land planning and use on the left bank of the Senegal river. It was conceived by CIRAD, funded by FAC, is run by SAED and functions on the basis of information exchanges with development agents.

At the same time, SAED and BDPA used satellite images to identify and number the project areas in order to map them.

Thanks to funds from FAC in 1994, the database was interfaced with the planning atlas. Planning modifications can be traced and maps drawn according to the data contained in this geographic information system, to which information on soil and water management will be added soon.

## SUSTAINABLE DEVELOPMENT IN THE SAVANNA AND HUMID TROPICAL ZONES

In the savanna, humid tropical and island zones, the climate is favourable for agricultural production, and populations increase and ecosystems evolve quickly. Sustainable growth will have to reconcile increased productivity with safeguarding natural resources: optimize farm production, improve product-market interaction and diversify rural activities.

### Diversity of the Cotton-Growing Region of Cameroon

The cotton-growing zone in northern Cameroon extends 400 km from north to south. There are 2.3 million people, 200,000 of whom are cotton producers, who live off the land in a wide variety of farming systems. Agronomic research and rural development organizations must take this diversity into account when they target their aid. The Garoua project had this in mind when it brought together IRA, IRZV in Senegal and CIRAD

### PUBLICATION

#### Agricultural Output Improvement Techniques in the Sudano-Sahelian Zone

Techniques d'amélioration de la production agricole en zone soudano-sahélienne *is a collection of 31 technical files on soil conservation and regeneration, improvement of plant and animal outputs, use of harvest residues and farm mechanization. It provides rural development staff with precise information concerning various technical innovations and presents the advantages and constraints for farmers wishing to adopt these innovations.*

to undertake a study of the diverse cropping and herding systems.

The field knowledge and statistics of the SODECOTON development agents and several livestock herding advisory services were used to describe and identify seven zones, each with its specific outline for development.

Thanks to this zoning, some of the Garoua project research programmes were refined to meet regional needs and new centres were set up on-site. This formed the basis of a study of farmer strategies in a cotton zone, organized by the Cameroon Ministère de l'agriculture and CIRAD and funded by the Caisse française de développement. Intervention on the part of development advisers is often

limited to a geographic area or to a sector; this study facilitates a region-wide view of problems, such as maintaining production levels in densely inhabited zones, settling migrant populations, natural resource conservation and the future of environment-protection sites.

### Multimedia Information System in the Amazon Basin

The Projet régional de planification et de gestion des aires protégées amazoniennes (Regional project for planning and management of environment-protection sites in the Amazon basin), funded by the European Commission and the Traité de coopération amazonienne, has taken a step forward with the creation of Simbiosea (Système d'information multimédia biodiversité-socio-économie en Amazonie—Biodiversity-socioeconomics multimedia information system for the Amazon basin). The purpose of this programme, for which CIRAD is providing technical advice, is to protect the biodiversity of the Amazon basin and to improve the living conditions of the local inhabitants. It concerns Brazil, Peru, Ecuador, Bolivia, Colombia, Venezuela, French Guiana and Surinam and is supported by the regional

technical cooperation network: Surapa.

The information about the Amazon basin that is available is dispersed, heterogeneous and based on diverse parameters. This considerably hampers an overall view of the forces at work in this vast geographic zone, a *sine qua non* for carrying out any project on sustainable resource management. The new Simbiosea project hopes to remedy this situation by a multidisciplinary approach to data processing. All the most relevant work of any nature that has been undertaken in the basin will be synthesized and transcribed to CD-ROM with help from the Maison de la géographie in Montpellier. This will constitute a reference file for defining and managing projects and a support for national and regional planning, as it will provide an overview of the structures and dynamics in operation throughout the Amazon basin.

### **Labour Organization in Réunion**

All people actively involved in Réunion's sugarcane sector are represented in ARMES, for which CIRAD has provided technical coordination since 1992. They run the technical committee and set up work groups to study and address problems of a technical, economic and human nature that have

## TRAINING

### **Mechanized Production Systems Management**

*A training course in mechanized production systems management has been organized by CIRAD in Montpellier every other year since 1988. Participants in this course, which receives funding from different sources, are mainly those responsible for mechanization in the framework of a development project or on large farms, in French-speaking African countries or in overseas territories and departments. The course lasts 11 weeks and is divided into two parts: technical knowledge of machines and their upkeep and maintenance. The course is taught in cooperation with the Chesnoy agricultural high school in Montargis; the organization and economic management of mechanization is taught by CIRAD, with participation from manufacturers, FNCUMA, FDCUMA and farmers. An introduction to new computerized management tools is included in this second part.*

caused a steady fall in production over the past 5 years. CIRAD also coordinates the activities of five labour organizations which are the king-pins of the two sugar industry modernization plans that have been outlined since 1974. These labour organizations are farmers'

cooperatives that work for almost 5,000 farmers, often undertaking big jobs that farmers would find difficult on an individual basis, mainly in land improvement. CIRAD provides technical assistance and coordinates their activities throughout the island to rationalize use of the equipment at their disposal (42 caterpillar tractors, 30 wheeled tractors).

## **PROMOTION OF RURAL OUTPUTS AND URBAN FOOD SUPPLY**

The Department has reinforced its presence in Africa and Latin America. In Africa, the rapid urbanization and the devaluation of the CFA franc in 1994 have led countries to request partnership programmes for urban marketing, installation of small food-processing plants and the diversification of uses for local produce.

### **Food Processing Research in Burkina**

A strategic plan for scientific research in food processing in Burkina is being devised by CIRAD



and the CNRST biochemistry and food technology laboratory. As was shown by a diagnosis of the food processing sector in 1994, most local food processing for urban consumption is done by small businesses. In addition, small or medium-sized businesses, which aim to take a part of the growing urban or export markets, are springing up alongside older industrial processing plants. The laboratory has therefore increased its capacity to reply to the growing demand of these small enterprises and now advises individual businesses on how to seek out new markets, diversify their products, improve quality and reduce production costs. In this way, local research accompanies the development of small food-processing firms.

### Plant Leaf Packaging

Although countries in the South use increasing amounts of packaging, they have neither the raw materials nor the processing industries necessary for making it. Studies have been carried out concerning new and traditional biopackaging in the hope of using agricultural raw materials and their by-products that are available locally to produce new and cheaper packaging, thus reducing imports and also contributing to environmental protection. Tree leaves have

### INTERNATIONAL MEETING

#### International Conference on Cassava Starch and Flour

*The new possibilities for promoting cassava growing concern a large part of the population in Africa, Asia and America. A conference on this topic was organized by CIRAD and CIAT in Cali, Colombia, from 11 to 15 January 1994. Researchers, development agents and industrialists exchanged notes on the production and use of cassava flour and starch in a wide range of food or industrial products.*

traditionally been used in hot countries to wrap produce. In Asia, they are also used as plates for street foods. Some leaves are specific to a product, others to a region, while others, like the banana leaf, are used in many ways. They are used in the conventional way—to protect, wrap individually—and in cooking and fermenting. These “active” wrappings can alter the taste, colour or texture of a product by substance transfer. This sector of leaf wrappings was studied by researchers from Brazzaville University, Congo, and from the agronomic sciences department of the National University of Benin, who were trained by CIRAD. In 1994, they proposed different ways of prolonging leaf life and improving functional properties—e.g. firmness, impermeability—by suitable pretreatment. These

techniques will subsequently be made known to users.

### Exchange of Know-How Concerning Maize Processing

Although maize cropping in the cotton-growing regions of Sahelian countries has increased over the past few years, it finds few outlets on the urban markets due to lack of variation in its use. In southern Benin, on the other hand, where maize is used in 40 different ways, it rates high in urban food habits. An exchange between Burkina and Benin was therefore proposed at the January 1994 seminar “Mais prospère” (Prosperous maize) held in Benin. This exchange is included in the programme “Innovations agroalimentaires et valorisation des savoir-faire locaux” (Innovations in food technology and use of local know-how) which is financed by the Ministère de la coopération et du développement and coordinated by CIRAD and the Université du Bénin and supported by Procelos, the CNRST laboratoire de biochimie et technologie alimentaire (biochemistry and food technology laboratory) and the Ministère de l’agriculture et de l’élevage (cropping and herding ministry) in Burkina.

Nine Benin products were tested in Ouagadougou by 40 consumers

## PUBLICATION

**Prosperous Maize**

*The report of the regional seminar "Mais prospère" held in Cotonou from 25 to 28 January 1994 has been published. The seminar was organized by CIRAD and the Faculté des sciences agronomiques of the Université nationale of Benin, with support from FAO, to discuss maize production and promotion in West Africa.*

who then listed their preferences. Recipe files were compiled. Two Burkina women took courses from women in Benin, then together organized a teaching course for 25 women in Ouagadougou. The operation will continue with a technical follow-up of the women already trained and an extension of the teaching programme. Other products are being targeted in similar programmes in Benin, Senegal and Burkina.

**Adding Value to Amazonian Products**

Family farm productivity can be increased without depleting natural resources. A programme to improve storage, marketing and processing of farm produce was launched in 1993 in the Marabá and Altamira regions, pioneer-front zones of the Amazon basin where farming is characteristically unstable. The programme is being

carried out jointly by technologists and economists, from EMBRAPA's CPATU (East Amazonian centre for agroforestry research), the Pará Federal University in Belém, local organizations and CIRAD's livestock production and veterinary medicine department and has received financial backing from the French Ministère des affaires étrangères.

Rural economics and the processing experiments that existed already were studied in 1994, and led to research work on various products.

Different ways of storing rice by pioneers from different regions were assessed and compared.

A particular quality of cassava flour should find a corner of the market in competition with industrial flours from the South.

Quality control, processing equipment and a regional brand marketing policy will improve coffee and cocoa sales.

As the hectareage taken over by large livestock herding concerns increases, small farmers are pushed far from the main communication routes and services. Mixed herding-cropping systems, e.g. making cheeses to add value to milk, would enhance their land use.

Cupuaçu (*Theobroma grandiflorum*) produces a sweet pulp which could be used in many

ways. A marketing test involving 4.8 t of cupuaçu pulp was carried out in 1993–94 with the Marabá cooperative. During 1994–95 20 t are being tested and processing of the beans has begun.

**LOCAL DEVELOPMENT AND INSTITUTIONAL DYNAMICS**

Governments are withdrawing their support from many rural and food technology development schemes and are being replaced by new types of organizations. The Department is getting to know the new organizers, their strategies and initiatives, so as to devise innovative ways of supporting local development.

**Albanian Development Foundation**

As in other countries of Eastern Europe, the economy in Albania has been liberalized. Land has been distributed, but small private farmers cannot obtain bank credit for lack of sufficient guarantees, and the amounts they require are too insignificant to be of interest to formal financial institutions.

## INTERNATIONAL MEETING

### International Symposium on Systems-Oriented Research in Agriculture and Rural Development

*More than 700 people from 70 countries participated in the international symposium on systems-oriented research in agriculture and rural development held in Montpellier from 21 to 25 November 1994 at the initiative of European scientists. Two hundred and sixteen communications were presented, 27 of which were by CIRAD, thus confirming the breadth of the research carried out in rural environments in cooperation with the farmers. It was the 13th symposium held under the aegis of AFSR/E and the first held outside the United States. It was organized by CIRAD, AGRINET, CIHEAM-IAMM, CNEARC, GRET, INRA and ORSTOM.*

*The debates focused on seven themes: modernizing methodology, managing natural resources, high input agriculture, indigenous knowledge, local organizations, training and agricultural policies.*

A decentralized savings and credit body has been created by ADF (Albanian Development Fund), backed by the World Bank and other donors, with technical support from CIRAD.

The privatization of State farms and cooperatives in 1992 resulted in the creation of many small mountain farms. It was clear, according to the first assessments made, that these new farms needed funds for inputs, tools and livestock to enable them to recapitalize. A credit system based on village social structures was set up and managed by an ADF team of professionals. A credit committee elected by farming families in each village directs a village credit fund and determines allocations based on an investment project's economic viability and the reliability of the borrower.

Three thousand farming families in 70 villages were involved in the project by the end of 1994. Debt recovery was 100%. A positive assessment of the first 3 years encourages the move to a mutualist banking system, whereby the village funds would be transformed into credit associations. The legal framework is being structured and new staff are being trained to respond to increasing growth capacity so that the problems of rural financing can be dealt with on a national level.

#### On-Farm Experiment

One of the priorities of PRIAG is to ensure that farmers

participate actively in research and in the spread of competence and technology. The six Central American countries are partners in the programme whose European technical support is provided by CIRAD and KIT. In Guatemala, Honduras, Nicaragua, Costa Rica and Panama spontaneous groups of farmers are helped to carry out their own experiments by field teams made up of researchers and extension agents from the public sector.

These same teams grafted part of their own research onto that of the villagers in their sectors, providing complementary data on such problems as soil fertility, adapting new varieties, crop protection using locally available products (chemicals, etc.) and mixed cropping. About 450 experimenting farmers were organized into 30 groups.

In Nicaragua, PRIAG provided methodological support to the national professional farmers' association, which sought to reinforce the technical help provided by its department (Campesino a campesino) to farmers' experiments. Three regional 1-week training workshops were organized in 1994 for all these technicians.



## PUBLICATION

**Support for Rural Producers**

*L'appui aux producteurs ruraux is a practical guide for use by development agents and managers of farmers' organizations. The document was compiled collectively by experts belonging to various bodies and discusses the possible components of farm-level support for farmers according to their needs. It presents approaches, methods and material that have all been tested in real situations.*

## THESES COMPLETED IN 1994

## CIRAD Scientists

**Des rizières aux paysages : éléments pour une gestion de la fertilité dans les exploitations agricoles du Vakinankaratra et du nord Betsileo (Madagascar)** [Rice paddies on the landscape: elements for fertility management on farms in Vakinankaratra and in North Betsileo (Madagascar)] by Dominique Rollin, Université Paris X, Nanterre.

**Optimisation des procédés combinés de déshydratation-imprégnation par immersion (dans des solutions concentrées) et de séchage par entraînement (à l'air chaud)** [Optimization of the combined processes of dehydration-impregnation through immersion (in concentrated solutions) and hot-air drying] by André Themelin, Ecole nationale supérieure des industries agricoles et alimentaires, Massy.

**Modernisation des espaces ruraux et paysannerie. Le cas du Nordeste du Brésil** [Modernization of rural land-use and the farmers. The case of Nordeste, Brazil] by Jean-Philippe Tonneau, Université Paris X, Nanterre.

**La diffusion du maïs au nord du Cameroun. Dynamique de l'innovation et culture technique locale** [Maize distribution in northern Cameroon. Traditional technology and innovation dynamics] by Abrao Silvestre, Ecole des hautes études en sciences sociales, Paris.

**De la norme à la diversité : l'intensification rizicole face à la diversité paysanne dans les périmètres irrigués de l'Office du Niger** [From standard methods to diversity: rice crop intensification and farmer diversity on the irrigated perimeters of the Office du Niger project] by Jean-Yves Jamin, Institut national agronomique de Paris-Grignon.

**Contrôle de l'espace et développement rural dans l'ouest Alaotra. De l'analyse d'un système agraire à un projet de gestion de l'espace rural (bassins versants de l'Imamba et de l'Ivakaka, lac Alaotra, Madagascar)** [Environmental protection and rural development in West Alaotra. From the analysis of a farming system to a rural land management project, Imamba and Ivakaka River basins, Lake Alaotra, Madagascar] by André Teyssier, Université Paris I.

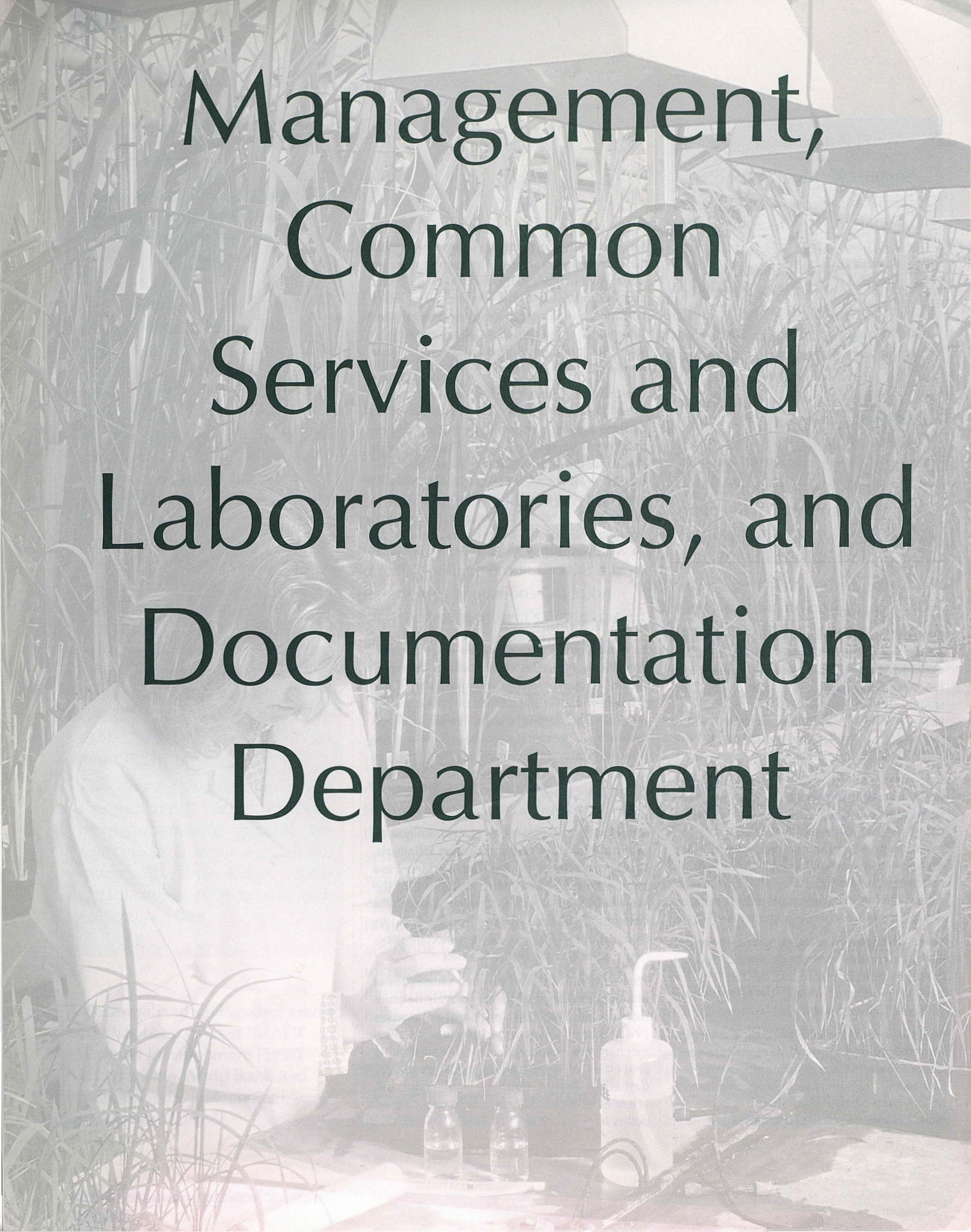
## CIRAD Trainees

**La dynamique d'offre de cacao entre marché, conditions naturelles et institutions. Interprétation à partir d'une comparaison Côte d'Ivoire-Malaisie** [Dynamics of cocoa supply related to marketing, natural conditions and institutions. Interpretation based on a Côte d'Ivoire-Malaysia comparison] by Françoise Jarrige (France), Faculté de science économique et de gestion, Université de Bourgogne, Dijon.

**Modélisation agronomique et économique de la durabilité d'un système agraire villageois. Le cas du village de Bala au Burkina Faso** [Agronomic and economic modelling of the sustainability of a village farming system. The case of the village of Bala in Burkina Faso] by Bruno Barbier (France), Ecole nationale supérieure agronomique de Montpellier.

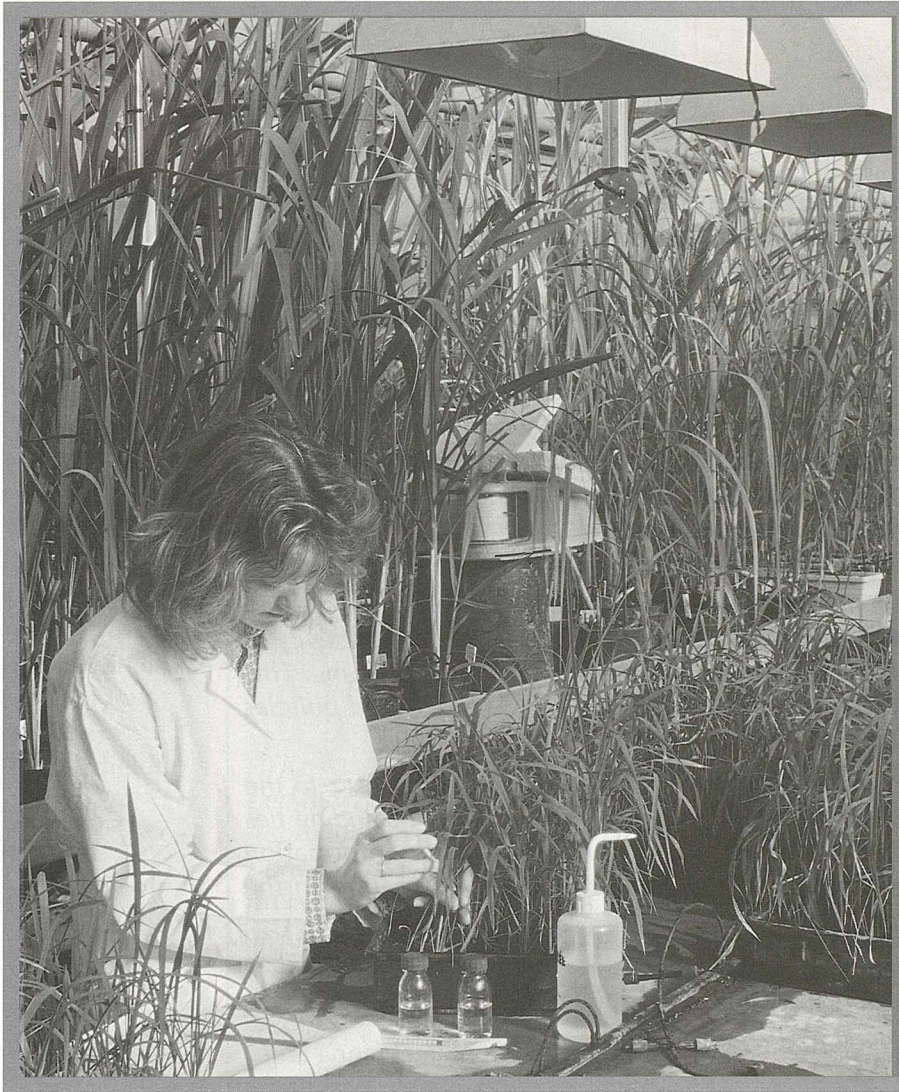
**Etude des mécanismes physico-chimiques et biologiques responsables du pouvoir de panification de l'amidon fermenté de manioc** [Study of the biological and physico-chemical mechanisms responsible for bread-making properties of fermented cassava starch] by Catherine Brabet (France), Université des sciences et techniques du Languedoc, Montpellier II.



A scientist in a white lab coat is working in a laboratory. The scientist is holding a small plant or specimen. In the foreground, there are several small glass vials and a white plastic bottle with a pump dispenser. The background is filled with various types of plants, including tall grasses and leafy greens. The overall scene is a laboratory setting with a focus on plant research.

# Management, Common Services and Laboratories, and Documentation Department





**C** IRAD-GERDAT's strategy to become more strongly rooted in the Languedoc-Roussillon region began to bear fruit in 1994. Like their colleagues at Biotrop, the biotechnology for tropical crop improvement laboratory, the Department's programmes and research units have strengthened their cooperation ties with Montpellier's university and research bodies.

As a preliminary result, the operational ecology and acridology programme, Prifas, specializing in locust surveillance and control, has joined



with Agropolis in setting up a European Master's degree programme in acridology, in association with Montpellier University and INRA, among others.

The soil and plant analysis unit and ORSTOM's environment and farming activities department are negotiating an agreement to work together on soil chemistry. This should be signed in 1995.

The plant architecture modelling unit has been working with INRA for more than 4 years on tree architecture. They have suggested making their AMAP software available to Agropolis for regional land-use planning. The three-dimensional images of plants and their evolutionary simulations produced by AMAP can be very useful to landscape designers.

Green, the renewable resources and environment management research unit that was created in July 1993, has already set up part of its activity in Montpellier; e.g. a laboratory specializing in multi-agent systems. This follows the move by a branch of the agricultural prospects and policies research unit to Montpellier.

This delocalization of the Department brings it logically closer to the Mediterranean scientific community with whom it has long-standing ties via its central training, computer, technical and scientific information services, and opens the way to the Department's participation in the dynamics of the region.

## OPERATIONAL ECOLOGY AND ACRIDOLOGY

CIRAD's operational ecology and acridology programme, Prifas, has focused its research, training and information on locust survey and control. In 1994, Brazil was the location chosen for experiments involving new insecticides that aimed to assess the effects of chemical antilocust

treatments on nontarget fauna and to redefine the country's locust control strategies.

### The Search for a Dieldrin Substitute

Dieldrin, an organo-chlorinated contact pesticide, was used for years in preventive control of the desert locust. When used in low volumes for barrier treatment, the product's persistence made it effective over vast areas, making it indispensable for halting an insect

## MANAGEMENT, COMMON SERVICES AND LABORATORIES, AND DOCUMENTATION DEPARTMENT

### CIRAD-GERDAT

Director  
*Jean-Marie Sifferlen*  
Research Director  
*Philippe de Reffye*  
Administrative and  
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*Vincent Fabre-Rousseau*

### Research Programme

Operational Ecology and  
Acridology  
*Michel Launois*

### Common Services and Laboratories

Biotechnology for  
tropical crop improvement  
*Jacques Schwendiman*  
Plant architecture modelling  
*Philippe de Reffye*  
Agricultural prospects and policies  
*Michel Griffon*  
Renewable resources and  
environment management  
*Jacques Weber*  
Soil and plant analysis  
*Paul Fallavier*

### Support Services

Training  
*Marc Roesch*  
Scientific and  
technical information  
*Jean-François Giovannetti*  
Computer services  
*Joël Sor*  
Physical plant and maintenance  
*Didier Servat*

## PUBLICATIONS

**Locust Information in Sub-Saharan Africa**

*Any preventive locust control relies on field information that must be gathered, forwarded analysed and stored. CIRAD and OCLALAV made a survey on the subject in 10 West African countries in 1992 and 1993. A publication entitled L'information acridienne dans les pays membres de l'OCLALAV, which presents the results of the enquiry, was published in 1994 with backing from the French Ministère de la coopération.*

**Natural Enemies of the Sahel Locust**

*Thanks to funds from the Netherlands, Prifas contributed to the compilation and publication of a book entitled Les ennemis naturels des criquets du Sahel, part of a collection of books on operational acridology brought out by CIHSS, and in keeping with its policy of publishing scientific results for the general public.*

invasion. It was banned in 1987 and no pesticides used since have been as effective.

In 1994, CIRAD carried out experiments in Mauritania, in cooperation with the Mauritanian Ministry of rural development and the environment, on a new compound developed by Rhône-Poulenc. Fipronil was tested in a natural desert locust reproductive zone to assess its potential under real conditions. This new pesticide was found to be persistent and extremely effective at ultra low volumes in barrier treatments, without the drawbacks of dieldrin.

Fipronil might well become the substitute product yearned for by the countries which are prey to these pests. Until nonchemical control methods have been perfected, it will be vital to these countries to be able to rely on a more efficient and less costly active ingredient than they have had at their disposal over the past 7 years.

**Effects of Chemical Control on Nontarget Fauna**

CIRAD and the Burkina Direction de la protection des végétaux et du conditionnement studied the effects of chemical treatments on nontarget arthropods, spiders and other insects during 2 successive growing seasons in 1992 and 1993. Their aim was

to assess the impact of pesticides on these populations and the subsequent recolonization rate in the treated plots. The data were processed in 1994. Results showed that, apart from elaterids (click beetle), all taxons are affected by antilocus treatments, especially the Hymenoptera, many of which are useful parasitoids. Chemical spraying usually leads to a sharp

decrease in these populations, even if only temporarily. Arthropods that live in the soil, however, appear to be protected by grass cover.

**A Strategy for Locust Control in Brazil**

CIRAD and EMBRAPA, backed by the European Commission, launched a research project in 1993 to study the locust of Mato Grosso, *Rhammatocerus schistocercoides*. Outbreaks were found to be determined by rainy conditions at key moments in the insects' biological cycle. Since the species is fairly sedentary, preventive action against the pest, i.e. detection and destruction of hatching sites during the rainy season, becomes possible. The locust biotope maps that were drawn with the help of Landsat images will be used to develop such a strategy.

**BIOTECHNOLOGY FOR TROPICAL CROP IMPROVEMENT**

Biotrop, the biotechnology for tropical crop improvement unit, concentrated its activities in 1994

in two major fields: first, genome mapping of the main tropical crop plants and their genetic transformation through analysis of *Bacillus thuringiensis* toxins; second, improving embryogenic cell suspensions, the medium for transformation methods.

### Comparative Mapping of Grain Genomes

Molecular markers, especially RFLP, have been used to map numerous crops over the past 10 years. A very similar genome arrangement was often found in plants of the same family, especially in the graminaceous Poaceae.

Similarities were first found between wheat, barley and rye (Triticeae). Subsequent comparison of the genetic maps of plants belonging to different groups, such as rice, wheat and maize, confirmed that large colinear zones were conserved on the family scale.

CIRAD is comparing sorghum and sugarcane genomes with maize probes. These three plants belong to the Andropogoneae group. Comparison of their genomes has already revealed that they have about 100 molecular markers in common. Sugarcane and sorghum have very similar linkage groups. Maize has a more complex genome structure, characterized by

many duplicated chromosome regions. Since the three grains split to develop along different lines, maize seems to have undergone massive chromosome rearrangements. However, the three species have, for the most part, kept the same marker order within linkage groups which accounts for a near perfect colinearity over large intervals.

Genetic mapping of grain plants should progress rapidly with the coordination of research work on related grains and intensified research on simple models, such as rice or sorghum.

### Measuring *Bacillus thuringiensis* Toxins

*Bacillus thuringiensis*, a soil bacterium, produces proteins that are toxic for a number of pest insect groups. Several techniques have been developed to assess the efficacy of these toxins, which varies according to the bacterium strain and the insect.

Immunocytochemistry and laser scanning cytometry complement each other. The former reveals the presence of toxin receptors on intestinal epithelium microvilli. The latter is used to visualize and quantify their localization in different parts of the intestine. In the midgut of the rice striped stem borer, *Chilo suppressalis*, CryIA(a) and CryIA(c) toxin binding sites are

distributed evenly, contrary to those of CryIB, and are more numerous in the anterior and posterior zones. There are few CryIA(b) receptors. No receptors were found for CryIC and CryIE.

Laser scanning cytometry can detect toxins which have been marked with different fluorochromes to determine whether they compete for the same receptors. Receptor binding, studied on brush border membrane vesicles, was determined with radioactive markers. CryIA(a), CryIA(c) and CryIB, which are active against the rice striped stem borer, were studied two by two using this method, and with the help of the Institut Pasteur. They have two receptors in common: one is not very specific, and is abundantly and evenly spread throughout the insect's intestine; the other binds differently according to the toxin. CryIA(a) also binds readily to a third, less frequent, site.

When the effects of each toxin, on its own and with other toxins, are known, it will be possible to introduce genes coding for the most efficient toxins, whose activity would be synergistic, into future transgenic rice strains. At the same time, CIRAD and University of Montreal (Canada) are studying the activity of little-known toxins. Detailed study of the mechanism that leads to the destruction of



insect intestinal cells should make it possible to produce new and more efficient toxins and to delay resistance build-up in target insects. Researchers have chosen to study toxins that are specific to *Plutella xylostella*, a formidable food crop pest in temperate and tropical zones.

The activity of the *Bacillus thuringiensis* toxin is two-staged. First, it binds to the receptor on the epithelial membrane surface, activating cell signal mechanisms (calcium and pH). Then it creates a pore, thus disturbing the ion exchanges which in turn alter the cell's physiology, quickly leading to its destruction.

The toxin comprises two parts of about 300 amino acids each. That called "channel field" seems to be involved in creating the pore; the second, called "receptor field", in recognizing binding sites.

The aim is to combine in chimera genes the region coding for the channel field from one toxin with the region coding for the receptor field from another toxin, thereby elucidating each part's role in the toxin's toxicity.

Five of the six constructions planned were carried out in 1994 and the last is in progress. The receptor field of CryIE, which is inactive against *P. xylostella*, was combined with the channel fields of active toxins CryIA(b) and CryIC and, inversely, the CryIE channel

field was combined with the CryIA(b) and CryIC receptor fields. CryIC receptor field was also combined with the channel field of CryIA(c), which is a more efficient pore-creating toxin. These chimera toxins will be tested in vivo, in vitro and on reconstituted membrane systems (plane lipid bilayers).

### **Banana and Hevea Somatic Embryogenesis**

Of all main crops the *Musa* genus (banana) is that most often regenerated by in-vitro culture. If in-vitro plant production costs were reduced by use of somatic embryogenesis, which is a very efficient propagation system, more plants could be distributed. New methods for banana genetic improvement (genetic transformation, protoplast fusion) could complement more traditional improvement methods.

CIRAD has continued research on the development of this technique ever since it achieved success with zygotic immature embryos. Researchers have developed an embryogenesis system from male flowers in cooperation with CATIE as part of a European Commission project. Embryogenic suspensions were obtained for several cultivars of agronomic interest (Grande Naine, French Sombre). Field testing for conformity in bananas produced

from suspension regeneration is currently under way.

The process is also useful in banana transgenesis. CIRAD is developing a method which uses biolistics as a gene transfer technique and embryogenic suspensions as the target.

In *Hevea*, the past few years have shown that it is possible to obtain embryogenic calluses from the inner seed coat. These calluses, however, become cankered little by little and after 5 or 6 months the process has to be triggered again from the original explant. It is therefore altogether too slow for mass regeneration.

In 1994, the laboratory obtained the first durable embryogenic stock from clone PB 260, a clone of particular industrial interest. This very friable callus is reproduced by successive replanting every 3 weeks. Its multiplication rate—3 to 4 at each replanting—is practically infinite. It has a regeneration capacity of several hundred embryos per gram. Since then, stocks have been obtained from PR 107, another clone well known to planters.

CIRAD and ORSTOM are investigating how to improve cryopreservation of these stocks, to store them indefinitely. Embryo maturation is also under study by researchers seeking to improve its germination rate, which is currently about 10%.

## PLANT MODELLING

Plant improvement schemes, agroforestry or land-use planning are all fields where plant and plant growth modelling can apply. This was clearly demonstrated in 1994 when plant modelling software was put to use in eucalyptus plantation management, forest fire prevention and the setting up of a horticultural business.

### Eucalyptus Plantation Modelling

About 40,000 ha of eucalyptus were planted by UAIC, Congo, with help from CIRAD-Forêt. Quantification of these forests' biomass is made possible by using remote sensing. CIRAD proposed to model the architecture and growth of the main clones planted in order to obtain a more precise understanding of the radar image assessments.

Field data concerning trees of all ages, essential to the creation of the mathematical models, were collected over 2 years by UAIC technicians trained by CIRAD botanists.

CIRAD researchers in cooperation with the Centre d'études spatiales et de rayonnements simulate radar waves on these models. Radar data can thus be translated more

specifically with more precise quantitative and qualitative assessments of wood yield. The margin of error for the estimated plantation biomass can be reduced from 10 to 5%, which represents a lot of wood on the UAIC scale. Plantation production, both quantitatively and qualitatively, can be extrapolated over time using the software that simulates eucalyptus growth.

The modelling undertaken for this project will be of use in work currently conducted by CIRAD-Forêt to select and study the physiology of eucalyptus.

### The Spread of Mediterranean Forest Fires

The Mediterranean forest is particularly vulnerable to fire. The European Commission has funded research on the spread of fire in this environment in an effort to counter a disaster which destroys thousands of hectares in southern Europe each year. The aim is to create a software programme which would show how fire advances depending on the quantity and quality of combustible matter and its spatial layout.

CIRAD was asked by the French planning office (which is piloting the project) to create three-dimensional mathematical models of the Mediterranean forest. Research was carried out on the most prevalent species: Alep pine,

Provençale gorse (*Ulex*), kermès oak (*Quercus coccifera*), green oak (*Quercus ilex*), *Cistus villosus* and viburnum. Their architecture and growth were analysed by the modelling unit, then their distribution was reconstituted on the screen. After dividing the space into cubes, the software programme calculates the density of combustible matter per unit volume, an essential parameter for assessing the speed at which a fire will spread.

Although this research was carried out for a specific application—forest fire prevention—it also enhances botanical research through the acquisition of new knowledge about Mediterranean vegetation. For example, far more precise and comprehensive data are available on the Alep pine, from seed to 90-year-old tree. Data were also collected about the kermès oak (*Quercus coccifera*). It is now known that this tree, with its scraggy vegetation, hides the essential part of its woody biomass underground and that its seeds, reputed to germinate with difficulty, germinate abundantly at the edge of its leaf-cover area.

### Growth of Ornamental Tobaccos

The SEITA Institut du tabac asked CIRAD to undertake a study into the growing conditions and the development of several

ornamental tobacco varieties, to enhance its already rich collection of *Nicotiana* and this with the aim of diversifying their production.

An ornamental plant must comply with a number of well-defined criteria concerning shape, growth rate, transportation tolerance and growing conditions (season, planting soil, pot size, watering). Studies were conducted on five varieties over 2 years to collate the data necessary for mathematical modelling of their architecture.

The Amapsim simulation software conceived by CIRAD constructs synthetic images and visualizes plants at different times during their development, then models their growth in relation to parameters such as temperature or light. By simulating the influence of environmental factors on tobacco development, it calculates the time necessary for a plant to grow to marketable size and therefore the best sowing time, given market expectations.

## AGRICULTURAL PROSPECTS AND POLICIES

An external investigating committee assessed the work of this common services unit in 1994

and noted that it remains committed to the two bases of its methodology: prospect analysis and modelling. The unit will concentrate on two medium-term objectives to bring economic theory closer to real situations experienced by field staff and to propose methods of evaluating the outcome of economic policy measures.

### Agricultural Research and Development in Africa

CIRAD was asked by SPAAR to carry out a study to determine which particular aspects of research could contribute to the development of humid and subhumid zones of West and Central Africa.

Despite a number of preconceived ideas, this region has experienced successive periods of agricultural growth in which research played an important role. But the ideas put forward by researchers have had relatively little effect outside the field of agro-industrial plantations. Small farmers in general make use of only a fraction of the technical recommendations. They are interested in plant improvement, but often use fertilizers on annual crops, for immediate effect, without really changing their cropping habits.

National and international research organizations have a major role

to play in future changes in tropical agriculture. First and foremost, African export and food crops have to become competitive again. To this end, the study proposes that systematic research should be conducted to assess various sectors in order to stimulate productivity increases through cost reductions or quality improvement. Governments will not be able to totally abandon their support in key areas such as access to genetic material, chemical inputs and credit, even if they no longer ensure direct support to farmers, but still want to increase agricultural yields. And on a longer-term basis, research must help to develop sustainable cropping systems as an antidote to the exhaustion of arable land.

### Cooperation, Agriculture and the Greenhouse Effect

CIRAD carried out a study for ADEME in 1994 aimed at assessing which particular cooperation policies should be implemented in the agricultural sector to help reduce the gas emissions that contribute to the greenhouse effect.

About 16% of carbon dioxide and methane gases result from agricultural activities in Southern countries, due especially to deforestation (6%) and rice cropping (6%). Government policies can crucially influence gas emissions by regulating access to



land, food production, revenue distribution, product prices, and their encouragement of or lack of support for pioneer expansion and agricultural production. National economic policies are to some degree governed by international aid, mainly through structural adjustment programmes.

In general, the theoretical relationship between adjustment and the greenhouse effect is difficult to substantiate. The effect of any given measure on gas emissions is impossible to determine and its very impact can be forecast as positive or negative only if the economic, social and institutional context is known.

Two case studies, in Cameroon and in Costa Rica, showed that deforestation can be controlled only if measures are taken to develop intensive farming, though this often relies on specific public intervention that is in contradiction to adjustment rules.

### **Sustainable Agriculture and Bioeconomics Modelling**

A bioeconomics model has been devised to assess and compare the effects of agricultural and economic policies on renewable resources. The resource chosen was the soil, since the absence of data on soils and soil erosion frequently hampers the setting up

#### **PUBLICATION**

### **The Economy of Agricultural Policies in Developing Countries**

*CIRAD helped to conceive and edit Economie des politiques agricoles dans les pays en développement, published by Editions de la revue française d'économie. The work reflects the thinking of the French scientific community on this theme and is the result of concerted action led by the Ministère de l'enseignement supérieur et de la recherche.*

*It is presented in three volumes, but all are clearly interrelated. A preliminary series of contributions places developing countries' agricultural policies in their international economic framework and presents market tendencies, concepts and methods relating to sectors and competitiveness, examining some international farm product markets. This is followed by an analysis of the connection between macroeconomics and agricultural development. Experiments in Africa, Asia and Latin America are discussed, underlining the effects of foreign exchange and protection policies. Lastly, economic anthropology and the modelling of farmer behaviour contribute to the examination of the micro-economic bases of agricultural policies.*

of models that reflect reality and calls for more adequate methods.

This new decision-making tool was constructed using economic methods and a plant growth model which relates yield and the state of the soil to cropping habits. It also takes more account of the risk factor. In addition, it assesses the long-term and indirect effects of any economic measure concerning resources. It is based mostly on mesoeconomics that are better suited to the uncertainties of sustainable farming.

The approach is illustrated and validated by two case studies—a region in the Argentine Pampa, where maize is grown for export, and the village of Séguéré in Burkina, where food is produced for home consumption. Soil erosion in both cases was analysed in relation to various regulation and market intervention measures.

## **RENEWABLE RESOURCE MANAGEMENT, ENVIRONMENT**

A year and a half after its creation within CIRAD-GERDAT, the common services unit Green

(gestion des ressources renouvelables, environnement) broadened its action front to two other CIRAD Departments—Forestry (Forêt) and Food Technology and Rural Systems (SAR). Its many-faceted competence concerning renewable resources and its participation in numerous French and foreign networks gives it the ability to reply to questions on many fronts.

### Multi-Agent Simulation

A laboratory was created in Montpellier at the heart of this unit to use the “multi-agent modelling” techniques of artificial intelligence to simulate man-made ecosystems on computer and analyse their evolution according to different resource management schemes. Their models are still at the experimental research stage, but are used already to test the coherence of multidisciplinary approaches to a common problem—do the views of economists, agronomists and ethnologists coincide or diverge?

It is a powerful instrument for multidisciplinary dialogue and is being put to use in the framework of a thesis concerning management of the irrigated land bordering the Senegal river. The interactions and intercommunications of the various environments and people involved can be simulated

### PUBLICATION

#### Methane, Animals and Humid Zones

*Methane gas, which contributes to the greenhouse effect, is produced by wild and domestic bovines, termites, rice paddies and swamps. CIRAD and Ecole polytechnique have compiled a bibliographic assessment of methods employed to measure methane sources and wells. Emissions de méthane par les zones humides, les rizières et les animaux, analyse des méthodes de calcul is designed for use by nonspecialist researchers who might be confronted with these questions.*

and studied. At the same time, the laboratory is cooperating with CNRS, ORSTOM and Yaoundé University, Cameroon, on the simulation of a humid tropical forest ecosystem which is submitted to different uses to meet various needs.

#### Modes of Appropriation and Decision-Making Processes

Whatever the solutions found for managing renewable resources, their long-term validity will depend on the modes of appropriation and the nature of the decision-making processes involved in their application. This is true for afforestation in Burundi, protected forests in Mali, Niger’s need for firewood and a coherent agroforestry programme, fire control in Madagascar, etc.

Research showed that fire management in Madagascar had to be negotiated with the local communities and decentralized for even a short-term project to work. A study of protected areas confirms this. In Grande Ile, land expropriated from village common land was prohibited for farming, but gave rise to a phenomenon of freedom of access that endangered nature conservation efforts. It would seem that natural resources are protected only if appropriated by the local inhabitants and if nature conservation is in itself a source of income. Local management of common resources is a necessity, but this often entails tactful revision of the decision-making processes already in force.

Cooperation in this line of research with CNRS, INRA, the Muséum national d’histoire naturelle and ORSTOM is backed by the specialized international network, International Association for the Study of Common Property. The unit has set up a scientific seminar with the African Association pour la recherche et les études foncières where their results can be regularly presented and discussed. The Ecole doctorale en mathématiques de la décision (Université Paris IX) is participating in the work carried out on modelling decision-making processes.

## SOIL AND PLANT ANALYSIS

The soil and plant analysis unit's main function is to carry out mass-scale analyses for CIRAD researchers, but it now offers to do the same for research centres and companies in the Languedoc-Roussillon region in cooperation with ORSTOM and Agropolis. It shares its specific knowledge in the field of analytical chemistry and technical management of large laboratories through training courses and by participating in research programmes on methodology.

### Quality Control

Since its introduction into the world of laboratory analysis in 1990, quality control management has become essential. A 2-month tailor-made training course was organized in 1994 for two groups of seven Moroccan trainees. The first course dealt with quality management of the scientific material found in a laboratory. The second dealt specifically with quality control of analyses made by atomic absorption (heavy metal determination in marine samples).

### Screening Methods for Maize Resistance to Aluminium Toxicity

Studies are being carried out along two lines in the hope of finding rapid and early tests to screen maize varieties for resistance to aluminium toxicity.

One fairly general method quantifies root growth inhibition caused by excess aluminium, and focuses on maize plantlets grown in nutrient solutions similar in composition to those of the soil. In this way, the test can be adapted to the particular physical chemistry of any given soil—pH, aluminium concentration, phosphorus and nitrogen.

The other line of study is more fundamental as it attempts to clarify the phenomenon of aluminium toxicity. It is possible to measure ion exchanges immediately around the root system by chemical analysis of the agarose medium in which the plantlets grow.

These methods are being assessed in comparison with field tests carried out in a European Commission research programme.

### Analysis of Organic Acids in Soil and Roots

High-capacity complexing organic acids often play a major role where plant growth depends on toxicity or deficiencies.

A method for analysing maize root organic acids was developed in 1994. Since these acids readily bind aluminium, they have a detoxifying effect. The method is used to determine if the difference in toxicity resistance in maize varieties is due to the organic acid composition of their roots.

Quite a different approach led to a study of oxalic acid secreted by fungi in calcareous soil. As it precipitates with calcium in the immediate surroundings of the root system, this acid liberates the phosphate ions bound to calcium while reducing plant calcium uptake. Analysis of the acid is therefore useful in understanding the interactions that take place between roots and the soil.

These discoveries were made possible by recent advances in ion chromatography.

## TRAINING

CIRAD organizes training for its own personnel and that of its foreign partners. In 1994, 669 scientists received training, 370 of whom came from Southern



countries. The service handled 230 requests and set up 300 professional training courses compared with 240 in 1993.

### **Staff and Student Exchanges**

One of CIRAD's missions is to train young French and foreign scientists in research methods through doing research. The presence of a growing number of CIRAD researchers in developing countries encourages closer cooperation between Northern and Southern universities as well as shared field research projects. CIRAD research teams living abroad welcome into their midst students of all nationalities, in agreement with the host country. As a general rule, they bring together a Northern student for every Southern student to work on a project. This is enriching on both a scientific and a cultural level. In the same way, exchanges between Southern countries are encouraged. CIRAD has taken an active part in the South in the creation of scientific teams that are well integrated into regional and international research communities.

### **Degree Training**

CIRAD organizes degree training for researchers from partner countries within the framework of

degree-with-training contracts. It helps prepare entrance applications, sets out study plans (choice of university and training laboratory), and manages paperwork. In 1994, five PhDs were awarded, and five engineering and twelve BSc diplomas were awarded by French universities and polytechnics to CIRAD partner researchers from the South.

## **SCIENTIFIC AND TECHNICAL INFORMATION**

The central unit of scientific and technical information added an automated information system service to its documentation, library and publications services at the end of 1993. In reporting on its activities, the unit has decided to focus on the contribution made by this new service in 1994.

### **An Integrated Information System Concerning Scientific Activities**

The database concerning CIRAD agents, mission reports and research projects has been collated and centralized, endowing

the Centre with available information as to its research capacity at any given time in reply to internal or external requests.

This information about CIRAD activity has been sent to several international databases, which assemble and distribute information about agricultural research either in Europe or globally.

### **First Steps Along the Information Superhighway**

Since the beginning of 1994, CIRAD has been using a server to make available to Internet users information about the Centre, its activities and its results. The idea was to assess whether or not this type of diffusion was of interest to a research centre.

The answer is highly positive. The server has turned out to be an excellent internal communications base. Hypertext-type navigation is possible in a Windows environment thanks to the simplicity of the WWW (World Wide Web) interface. Any agent linked to the network has access to the database on researchers, missions and scientific projects, and will soon be able to consult the Centre's documentation database.

The server will become CIRAD's electronic window on the world.

## PUBLICATIONS

**The Third Edition of Sésame**

*The third edition of the Sésame CD-ROM of bibliographical references, which was published in 1994, contains 150,000 French-language references on tropical agriculture. Sésame is a fine example of North-South cooperation, with contributions from 32 European, African and South American institutions.*

**A Collection of Bibliographies on CD-ROM**

*Le riz au Cambodge, au Laos et au Vietnam de 1888 à 1991 is the first volume of Archiv-Doc, a new collection of complete bibliographies on CD-ROM. It was compiled with cooperation from the Centre national d'études et de ressources en technologie avancée and gathers together a database of 537 references and 28,000 numbered pages of full text which were indexed in a bibliographic study published in 1992 by CIRAD-CA. It cites numerous historical documents not readily available to the public.*

It will present information about the institution—such as organization charts and research projects, its annual report, a calendar of events—and will promote the Centre's products (software programmes, publications, equipment).

**COMPUTER SERVICES**

The unit spent 1994 planning the restructuring of CIRAD's computer communications network.

CIRAD sites in the Paris region, in Montpellier, Réunion and French Guiana are now all linked by direct lines, making it possible to by-pass servers and improving the reliability and confidentiality of in-house communications.

CIRAD local networks comply with Ethernet, the standard adopted by the international scientific community, and the TCP/IP protocol is used for centralized routing as well as personal interface. CIRAD thus has access, via the Réseau national de la technologie, de l'enseignement et de la recherche (Renater), to Internet which is used by more than 30 million people in 134 countries.

The computer stations have also been modernized. By the end of 1994, 350 PCs out of nearly 1,000 were Ethernet-equipped and connected to the network. Little by little all the terminals linked to the central computers will be replaced by this new equipment.

Troubleshooting monitoring has been installed on the network, advising the Computer Services

centre of any anomaly so it can be rapidly repaired and serious malfunctions avoided.

This infrastructure creates a new applications structure based on worksharing between the "client" PC and the server. The new tools at the user's disposal to develop applications adapted to this new structure combined with automatic access to the Web means that the user can "browse" through the network, thanks to the user-friendly Windows graphics interface, tapping the wealth of information to be found in vast databases and exchanging data in an ever-widening community, all from his or her workstation.

This opening out onto the world is mirrored within CIRAD where administrative, technical and scientific compartmentalization has diminished. This should engender fairly rapidly a new generation of less specialized applications, giving access to information on subjects such as personnel activities, accountancy, project progress, etc., and thus becoming a management tool of the future.

**THESES COMPLETED IN 1994**

CIRAD Scientists

**Politiques sur une agriculture durable, essai sur la gestion de ressources naturelles renouvelables** [Policies for sustainable agriculture, a

study of renewable natural resources management] by Daniel Deybe, Université Paris I.

**Des milieux, des poissons, des hommes : étude par simulation multi-agents, le cas de la pêche dans le delta central du Niger** [Environment, fish, men: a multi-agent simulation case study of fishing in the central delta of the Niger] by François Bousquet, Université Lyon I.

#### CIRAD Trainees

**Contribution à l'étude de la forme du cyprès méditerranéen (*Cupressus sempervirens* L.), variabilité génétique, architecture et modélisation de la croissance et de la ramification** [Contribution to the study of the shape of the Mediterranean cypress (*Cupressus sempervirens* L.), genetic variability, growth and structural architecture and modelling] by Françoise Bouroulet (France), Institut national agronomique de Paris-Grignon.

**Analyse et modélisation des processus de croissance et de développement qui contribuent aux performances agronomiques du pêcher *Prunus persica* L. Batsch.** [Analysis and modelling of peach tree growth and development processes in *Prunus persica* L. Batsch. contributing to its agronomic traits] by Dominique Fournier (France), Ecole nationale supérieure agronomique de Montpellier.

*The common services and laboratories units—Biotrop, Plant architecture modelling, Soil and plant analysis and Agricultural prospects and policies—also supported many theses listed under other CIRAD departments.*





# CIRAD at a Glance

Organization chart

Committees

Research coordination

Regional representatives

CIRAD worldwide

Budget

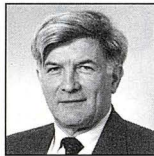
Personnel

CIRAD training

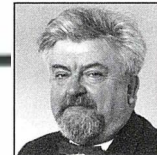
# ORGANIZATION CHART



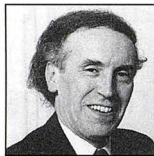
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*Michel de Nucé de Lamothe*



**Scientific Advisory Committee**  
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*Jean-Marie Sifferlen*



**Director, Montpellier Research Centre**  
*Gérard Matheron*



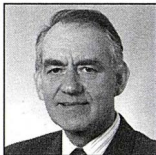
**Director, Research**  
*Didier Picard*



**Director, External Relations**  
*François Vicariot*



**Development Coordinator**  
*Christian Brunin*



**CIRAD-CA**  
Director  
*Jacques Lefort*



**CIRAD-CP**  
Director  
*Jean-Luc Renard*



**CIRAD-FLHOR**  
Director  
*Jean-Louis Rastoin*



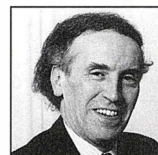
**CIRAD-EMVT**  
Director  
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Director  
*Jean-Marc Dubois*



**CIRAD-SAR**  
Director  
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# OF CIRAD IN 1995

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*Marc Gélis*

Personnel  
*Danielle Bonneau*

Legal affairs  
*Hervé de Font-Réaulx*

Computer services  
*Joël Sor*

Physical plant and maintenance  
*Didier Servat*

## French Overseas Departments and Territories

Regional Manager  
*François Pointereau*

Centre representatives  
(see page 116)

## Scientific and Technical Information

Head  
*Jean-François Giovannetti*

Publications  
*Michelle Jeanguyot*

Documentation, library  
*Marie-Gabrielle Bodart*

Automatic information systems  
*Jean-François Foucher*

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Africa, Indian Ocean  
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Latin America, Caribbean  
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International organizations,  
North Africa,  
Middle East  
*Marie de Latre-Gasquet*

Communication:  
Publicity  
*Anne Hébert*

Communication:  
Press relations  
*Benoît Catrisse*

Overseas representatives  
and correspondents  
(see page 116)

## Development

European Unit,  
applications  
*Alain Guyot*

Project monitoring  
*Claude Malvos*

## Research Administration

Deputy Director  
*Michel Eddi*

## Research Coordination

Crop and environment  
management  
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Plant improvement  
*Michel Jacquot*

Plant protection  
*Jean-Loup Notteghem*

Animal production  
*Gérard Matheron*

Technology  
*François Challot*

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Biometrics  
*Xavier Perrier*

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Internal auditor  
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**Hervé Bichat**, representing the Minister for Agriculture and Fisheries  
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## RESEARCH COORDINATION (1995)

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<i>Deputy coordinators</i>	<b>Jean-Joseph Lacoeyllhe</b> <b>Jean Pichot</b>
<i>Scientific committee</i>	
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<i>Scientific committee</i>	
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**Yves Gillon**, ORSTOM  
**Hervé Lecoq**, INRA  
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**Gérard Matheron**

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*External members*

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**Yves Darricau**, ONUDI

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**Jean-Anne Ville**, ANVAR

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**Michel Griffon**

*Scientific committee**Chairperson*

**Philippe Lacombe**, ENSA Montpellier

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<i>CIRAD members</i>	Departmental representatives

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<i>Scientific committee</i>	
<i>Chair person</i>	<b>Yves Escoufier</b> , Université Montpellier II
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<i>CIRAD members</i>	Departmental representatives

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### FRENCH OVERSEAS DEPARTMENTS AND TERRITORIES

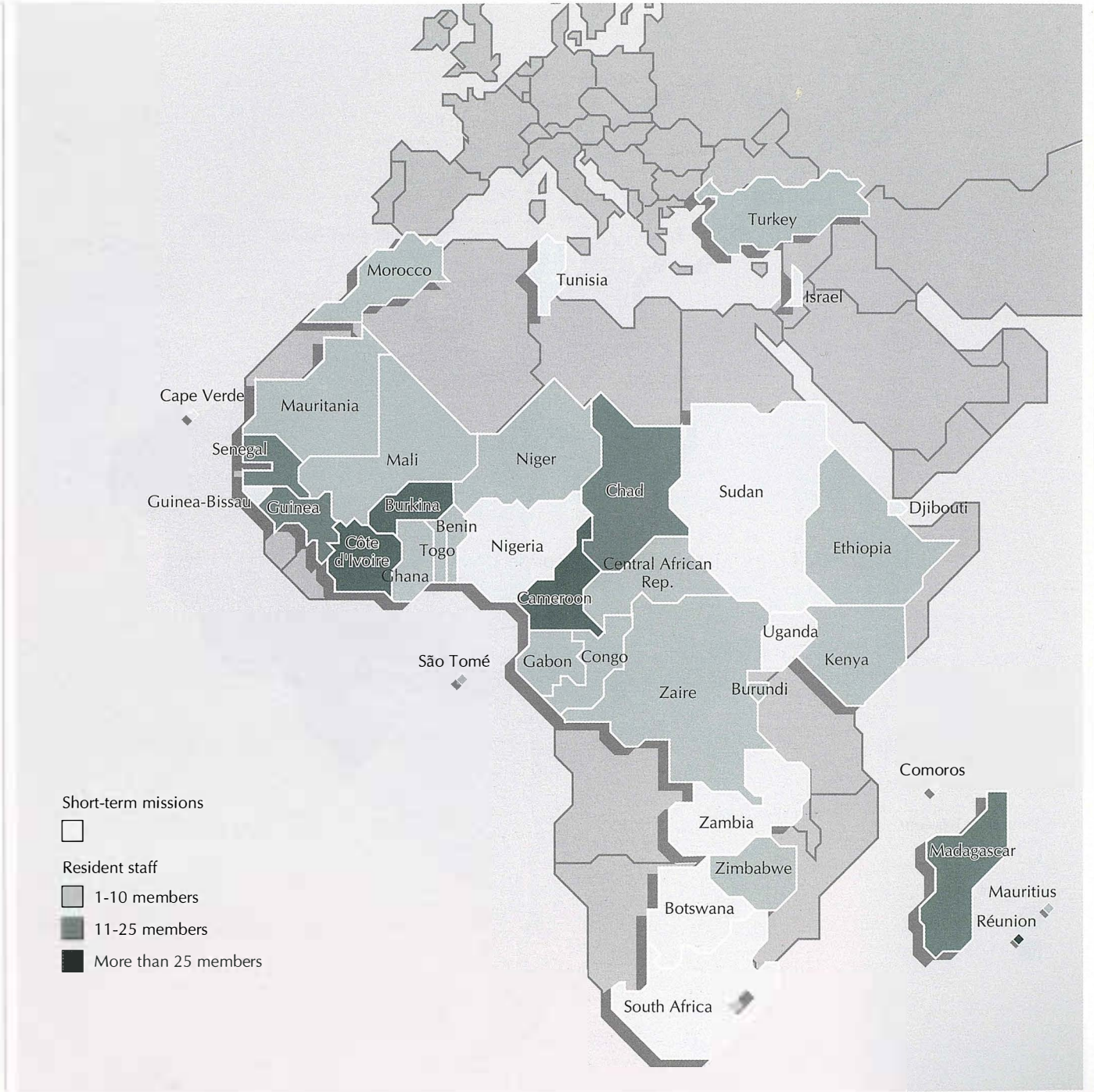
Guadeloupe	<b>Emmanuel Camus</b> , Representative
French Guiana	<b>Johann Huguenin</b> , Representative
Martinique	<b>Philippe Melin</b> , Representative
New Caledonia	<b>Claude Calvez</b> , Centre Director
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Réunion	<b>Paul Gener</b> , Representative

### OTHER COUNTRIES

Brazil	<b>François Bertin</b> , Representative
Burkina	<b>Jacques Dubernard</b> , Representative
Burundi	<b>Gérard Fourny</b> , Correspondent
Cameroon	<b>Patrice de Vernou</b> , Representative
Chad	<b>Daniel Bourzat</b> , Correspondent
Comoros	<b>Paul Gener</b> , Representative (based in Réunion)
Congo	<b>Olivier Hamel</b> , Correspondent
Costa Rica	<b>Jean Laboucheix</b> , Representative for Latin America and the Caribbean
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Gabon	<b>Franck Enjalric</b> , Correspondent
Guatemala	<b>Jean Laboucheix</b> , Representative (based in Costa Rica)
Guinea	<b>Jean Servant</b> , Correspondent
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Malaysia	<b>Patrick Durand</b> , Representative (based in Singapore)
Mali	<b>Jacques Dubernard</b> , Representative (based in Burkina)
Mauritius	<b>Paul Gener</b> , Representative (based in Réunion)
Nicaragua	<b>Jean Laboucheix</b> , Representative (based in Costa Rica)
Niger	<b>Jacques Dubernard</b> , Representative (based in Burkina)
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Vietnam	<b>Philippe Godon</b> , Correspondent
Zaire	<b>Jacques Monnier</b> , Correspondent
Zimbabwe	<b>Eric Féron</b> , Correspondent



# CIRAD IN AFRICA AND THE INDIAN OCEAN

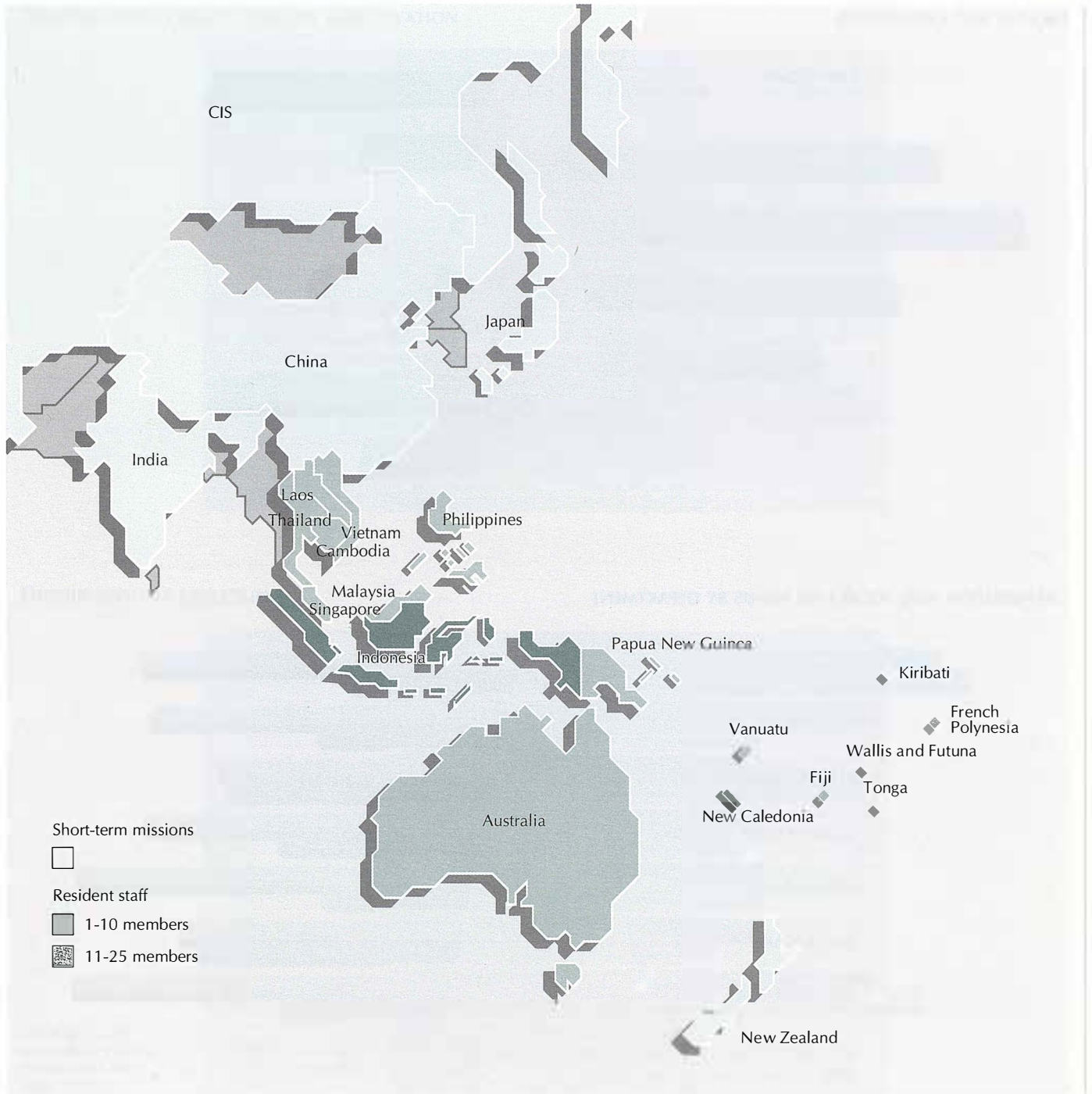


# CIRAD IN LATIN AMERICA AND THE CARIBBEAN





# CIRAD IN ASIA AND THE SOUTH PACIFIC



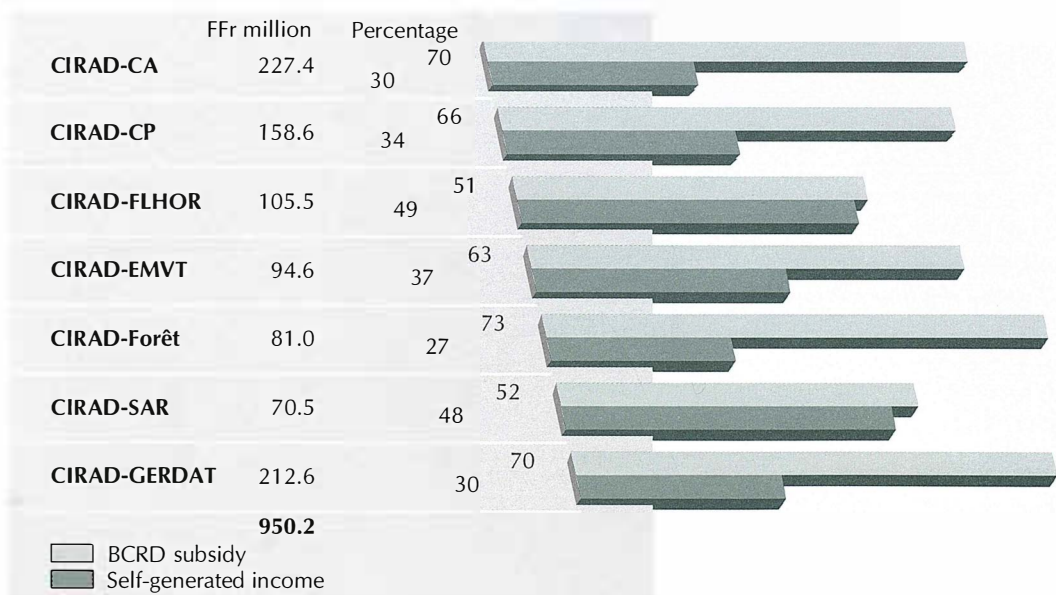


## 1994 BUDGET: FFR950.2 MILLION

### INCOME AND EXPENDITURE

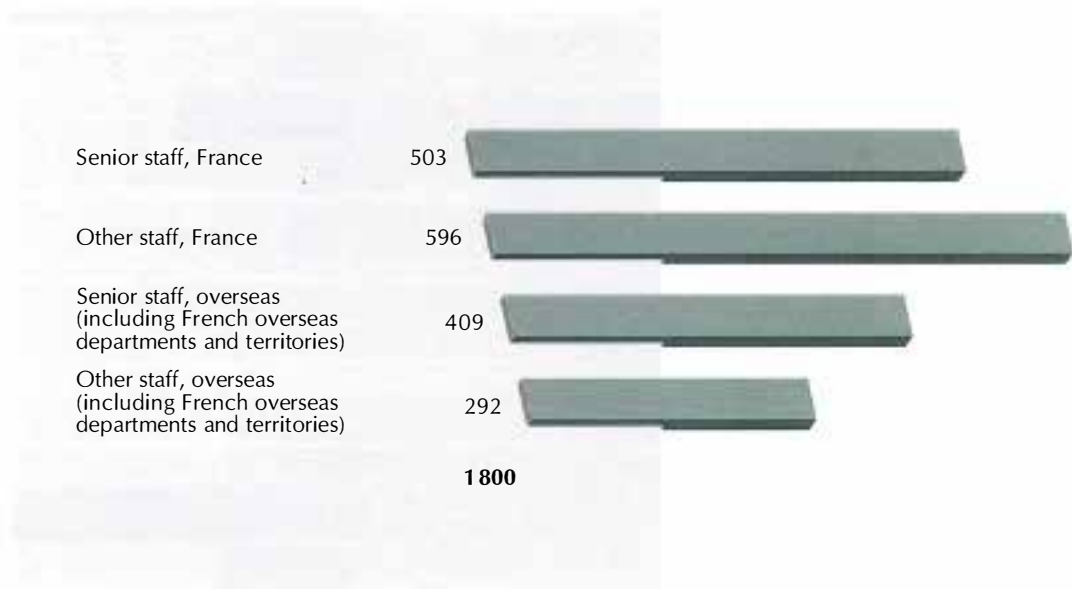


### DISTRIBUTION AND SOURCE OF FUNDS BY DEPARTMENT

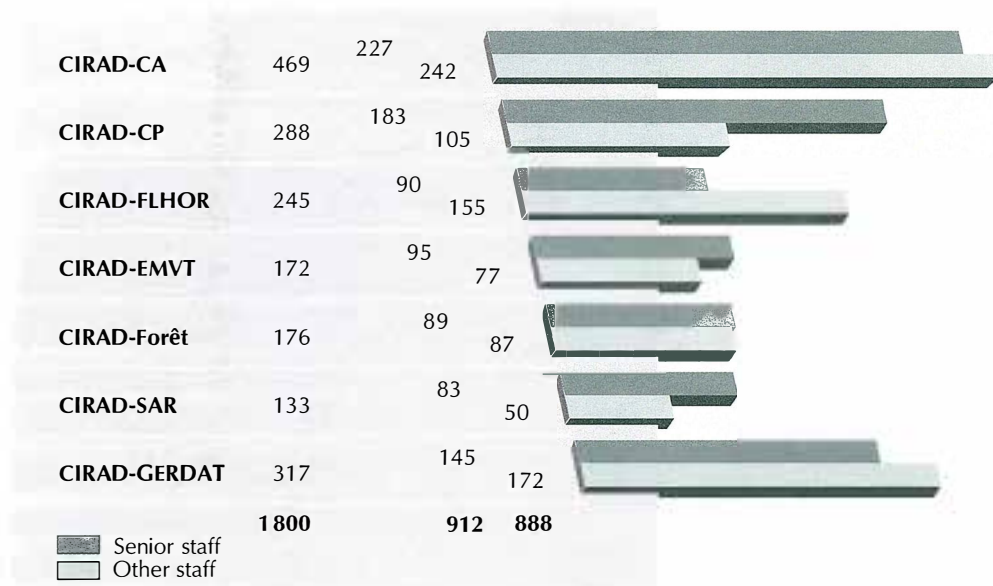


## 1994 PERSONNEL: 1800 STAFF MEMBERS\*

### DISTRIBUTION BY STAFF CATEGORY AND LOCATION



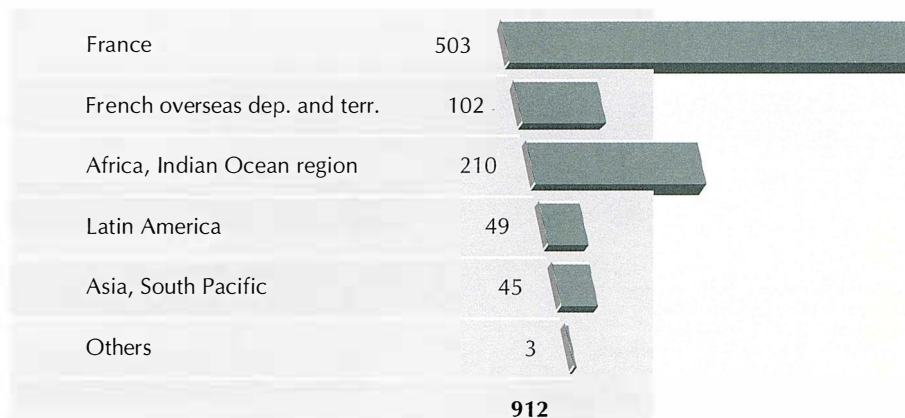
### DISTRIBUTION BY DEPARTMENT



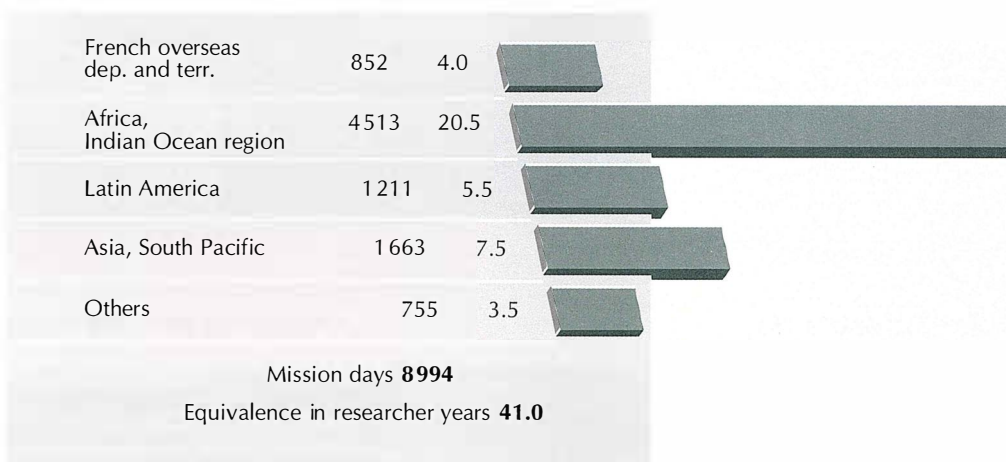
\*Excluding staff seconded to CIRAD, trainees, and daily wage workers.

## SENIOR STAFF: 912 MEMBERS

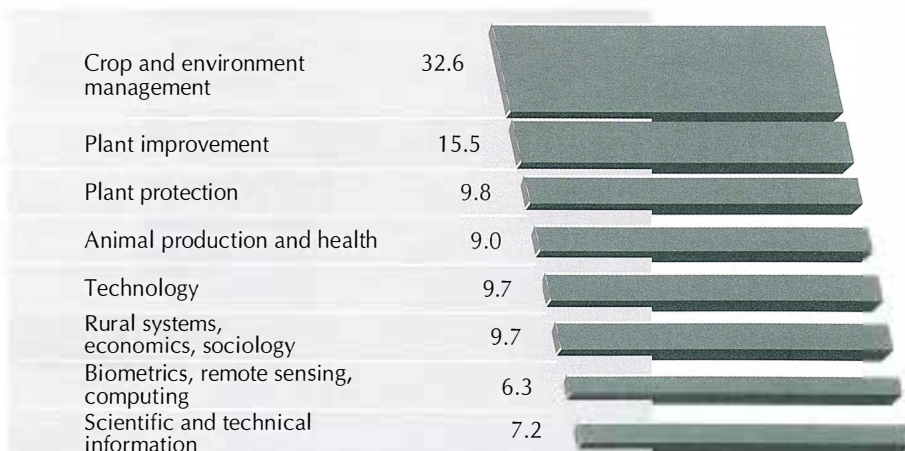
### GEOGRAPHIC DISTRIBUTION



### MISSIONS OVERSEAS INCLUDING FRENCH OVERSEAS DEPARTMENTS AND TERRITORIES



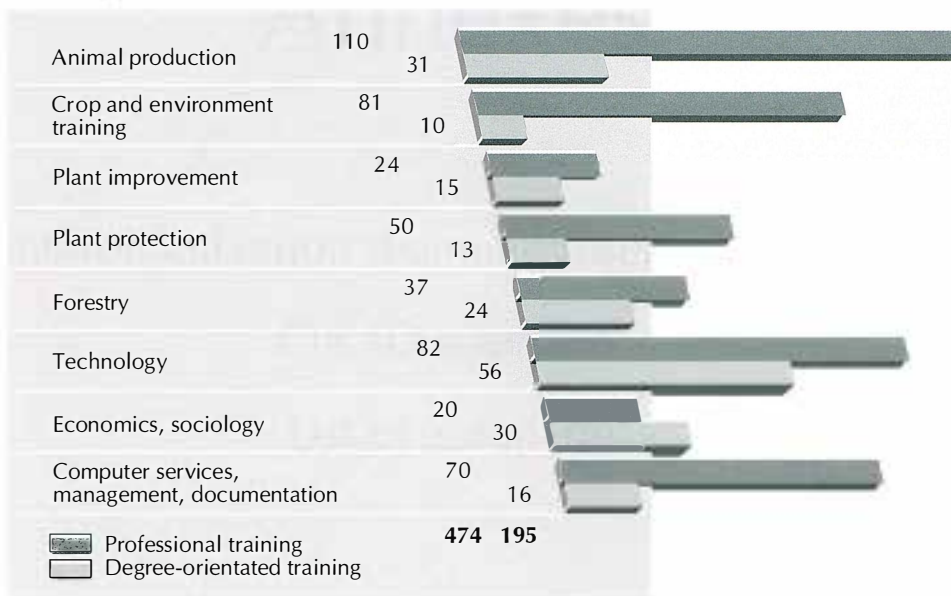
### DISTRIBUTION OF SCIENTISTS BY DISCIPLINE (%)



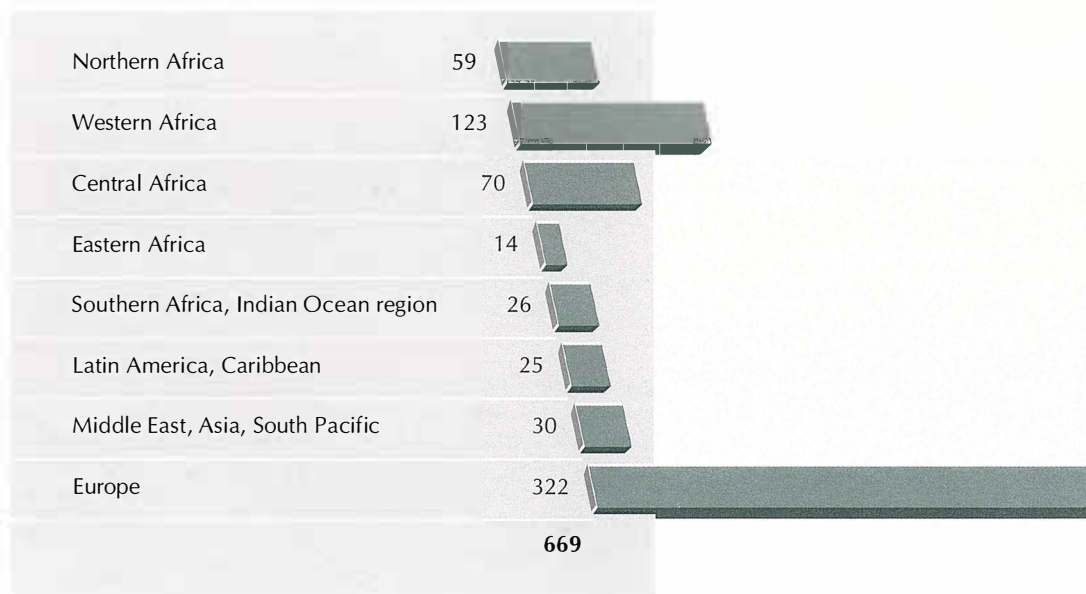


## CIRAD TRAINING IN 1994

### DISTRIBUTION BY DISCIPLINE AND TYPE OF TRAINING



### DISTRIBUTION OF SCIENTISTS BY GEOGRAPHIC ORIGIN





# Annexes

Interorganization thematic research projects

CIRAD addresses

List of acronyms



## INTERORGANIZATION THEMATIC RESEARCH PROJECTS FINANCED IN 1994

Work area	Theme	Partners
<b>CROP MANAGEMENT, ENVIRONMENT</b>	<i>Study of soil-machine interactions in mechanized tillage</i>	INRA, CEMAGREF, CNRS CIRAD-SAR, CIRAD-CA, CIRAD-FLHOR
	<i>Radiational transfer in coconut-cocoa intercrops. Simulation of optimum spatial arrangements by crop architecture modelling. Influence of the arrangement on the microclimate</i>	IDESSA (Côte d'Ivoire), INRA CIRAD-CP, CIRAD-GERDAT
	<i>Growth and development models for annual crops. Evaluation of existing solutions and applications</i>	INRA CIRAD-CA, CIRAD-CP, CIRAD-FLHOR, CIRAD-GERDAT
	<i>Reproductive organ formation and maintenance mechanisms in tropical plants as a basis for crop yield improvement: trophic factors in banana, cotton, groundnut and cowpea</i>	ISRA (Senegal), INRA, ENSA Montpellier CIRAD-FLHOR, CIRAD-CA, CIRAD-EMVT
	<i>Biomass flow and fertility management on smallholdings</i>	IRZV, IRA, Ministère de l'élevage, des pêches et des industries animales (Cameroon), IRCT (Chad), ORSTOM CIRAD-SAR
<b>PLANT IMPROVEMENT</b>	<i>Strategies for tree crop improvement</i>	INRA CIRAD-Forêt, CIRAD-CP
	<i>Development and improvement of haploid and doubled haploid plant production techniques</i>	Université de Zurich (Switzerland), ENSA Rennes, CNRS, Université de Toulouse CIRAD-FLHOR, CIRAD-CA, CIRAD-GERDAT
	<i>Development of gene transfer methods in tropical plants</i>	INRA, Université Paris VI, ORSTOM CIRAD-GERDAT, CIRAD-CA, CIRAD-CP, CIRAD-FLHOR, CIRAD-Forêt
	<i>Application of PCR techniques for genetic studies of tropical crops. Objectives and advantages</i>	CIMMYT (Mexico), INRA, CNRS CIRAD-GERDAT, CIRAD-CA, CIRAD-CP, CIRAD-FLHOR
	<i>Management of genetic resources: how to best preserve genes of agronomic interest</i>	IDEFOR (Côte d'Ivoire), CRBP (Cameroon), CRU (Trinidad), CDC (United Kingdom), ORSTOM, CNRS, INRA CIRAD-CA

Work area	Theme	Partners
<b>PLANT PROTECTION</b>	<i>Analysis of plant resistance components and application to plant breeding</i>	INERA (Burkina), CRBP (Cameroon) CIRAD-CA, CIRAD-FLHOR, CIRAD-CP
	<i>Use of sensitive plant pathogen detection techniques in modelling bacterial and virus diseases that hinder the development of fruit and vegetable crops in Réunion. Defining control strategies</i>	INRA CIRAD-FLHOR, CIRAD-CA
	<i>Analysis of the susceptibility of pest insects from different origins to Bacillus thuringiensis and the effects of toxic compounds on the insect populations</i>	ISRA (Senegal), CIMMYT (Mexico), NRI (United Kingdom), USDA (United States) CIRAD-GERDAT, CIRAD-CP, CIRAD-CA, CIRAD-FLHOR
<b>ANIMAL PRODUCTION AND HEALTH</b>	<i>Correlation analysis of the appearance of growth dimorphism in male Oreochromis niloticus (Cichlidae) and gonadic differentiation of sex and puberty. Role of steroid and growth hormones</i>	INRA, ORSTOM CIRAD-EMVT
	<i>Animal traction study: improving the efficiency of harness/tool assemblies</i>	IRA, IRZV (Cameroon), INRA, ENV Toulouse CIRAD-EMVT, CIRAD-CA, CIRAD-Forêt, CIRAD-SAR
	<i>Strengthening CIRDES' capacity for diagnosing blood parasites, using biotechnology</i>	ILRI (Kenya), GTZ (Germany), CIRDES (Burkina), Université Bordeaux II CIRAD-EMVT
	<i>Gastro-intestinal strongyloidiasis of small ruminants in tropical regions: genetic resistance and infestation environment</i>	ISRA (Senegal), CIRDES (Burkina), ITC (Gambia), ILRI (Kenya), INRA CIRAD-EMVT
<b>TECHNOLOGY</b>	<i>Conditions for the emergence and operation of rural food-processing enterprises</i>	University of Oxford (United Kingdom), Universidad de Córdoba (Spain), IICA (Costa Rica), DIMAC (Mexico), European Commission, Université Lyon II, Université Montpellier I, ENSIA CIRAD-SAR, CIRAD-CA, CIRAD-CP

Work area	Theme	Partners
<b>RURAL SYSTEMS, SOCIOECONOMICS</b>	<i>Packaging and environment in developing countries: biodegradable packaging</i>	Université de Brazzaville (Congo), ORSTOM, ENGREF, INRA, Université Montpellier II, CIRAD-SAR, CIRAD-CA, CIRAD-CP, CIRAD-Forêt
	<i>Modelling and optimization of frying processes</i>	SICOR (Côte d'Ivoire), CRBP (Cameroon), Univalle (Colombia), CNRIT (Madagascar), University of Jerusalem, Technicon (Israel), CNRS, ENSIA, CIRAD-SAR
	<i>Response of farmers' organizations to state disengagement</i>	ISRA, SAED, IRAM, CIEPAC (Senegal), CIRAD-SAR, CIRAD-EMVT, CIRAD-CA
	<i>Assessment of sector competitiveness</i>	SODEPALM (Côte d'Ivoire), ORSTOM, Université Paris X, CFD, Ministère de la coopération, CIRAD-GERDAT, CIRAD-CP, CIRAD-SAR, CIRAD-CA
<b>BIOMETRICS</b>	<i>Model used to assist decision-making in agricultural policies; application to diversification in Indonesia</i>	University of Berkeley, INRA, CERDI, CIRAD-GERDAT
	<i>Development of a statistical software package combining CSTAT and LISA</i>	ITCF, ORSTOM, CIRAD-GERDAT, CIRAD-CA, CIRAD-CP, CIRAD-FLHOR, CIRAD-EMVT, CIRAD-Forêt, CIRAD-SAR

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## LIST OF ACRONYMS

ACIAR, Australian Centre for International Agricultural Research, Australia

ADEME, Agence de l'environnement et de la maîtrise de l'énergie, France

ADF, Albanian Development Fund, Albania

AFNOR, Association française de normalisation, France

AFSRE, Association for Farming Systems Research and Extension, USA

AGRINET, European Network on Systems-Oriented Research and Rural Development, UK

ANVAR, Agence nationale de valorisation de la recherche, France

APPC, Alliance des pays producteurs de cacao, Nigeria

APPH, Association professionnelle pour la promotion hévéicole, Côte d'Ivoire

ARDA, Association réunionnaise pour le développement de l'aquaculture, France

AUPELF-UREF, Agence francophone pour l'enseignement supérieur et la recherche, Canada

AVRDC, Asian Vegetable Research and Development Center, Taiwan

BDPA, Bureau pour le développement de la production agricole, France

CAH, Commissariat à l'aménagement des Hauts, France

CARFV, Centre agronomique de recherche et de formation du Vanuatu, Vanuatu

CATIE, Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica

CDC, Commonwealth Development Corporation, UK

CEMAGREF, Centre national du machinisme agricole, du génie rural, des eaux et des forêts, France

CENIPALMA, Centro de Investigación en Palma de Aceite, Colombia

CERDI, Centre d'études et de recherches sur le développement international, France

CFD, Caisse française de développement, France

CFR, Centre français du riz, France

CFTRI, Central Food Technological Research Institute, India

CGIAR, Consultative Group on International Agricultural Research, USA

CIAT, Centro Internacional de Agricultura Tropical, Colombia

CIEPAC, Centre international pour l'éducation permanente et l'aménagement concerté, France

CIFOR, Center for International Forestry Research, Indonesia

CIHEAM-IAMM, Centre international des hautes études agronomiques méditerranéennes-Institut agronomique méditerranéen de Montpellier, France

CILSS, Comité permanent inter-Etats de lutte contre la sécheresse dans le Sahel, Burkina

CIMMYT, Centro Internacional de Mejoramiento de Maíz y Trigo, Mexico

CIRDES, Centre international de recherche-développement sur l'élevage en zone subhumide, Burkina

CITEPA, Centre interprofessionnel technique d'études de la pollution atmosphérique, France

CLVNET, Cambodia, Lao PDR, Vietnam Network, Thailand

CNEARC, Centre national d'études agronomiques des régions chaudes, France

CNPMF, Centro Nacional de Pesquisa de Mandioca e Fruticultura Tropical, Brazil

CNRI, Centre national de la recherche industrielle et technologique, Madagascar

CNRS, Centre national de la recherche scientifique, France

CNRST, Centre national de la recherche scientifique et technologique, Burkina

COLEACP, Comité de liaison Europe, Afrique, Caraïbes, Pacifique

CORAF, Conférence des responsables de recherche agronomique africains

CPATU, Centro de Pesquisa Agroflorestral da Amazônia oriental, Brazil

CRBP, Centre régional bananiers et plantains, Cameroon

CRU, Cocoa Research Unit, Trinidad

CSIC, Consejo Superior de Investigaciones Científicas, Spain

DFC, Deutsche Forst-Consult, Germany

DIMAC, Diversification et intensification dans la marge de l'aire caféière, Mexico

EMBRAPA, Empresa Brasileira de Pesquisa Agropecuária, Brazil

ENGREF, Ecole nationale du génie rural, des eaux et des forêts, France

ENSA, Ecole nationale supérieure agronomique, France

ENSAIA, Ecole nationale supérieure d'agronomie et des industries alimentaires, France

ENSI, Ecole nationale supérieure des industries agricoles et alimentaires, France

- ENV, Ecole nationale vétérinaire, France
- FAO, Food and Agriculture Organization of the United Nations, Italy
- FAC, Fonds d'aide et de coopération, France
- FCAP, Faculdade de Ciências Agrárias do Pará, Brazil
- FDCUMA, Fédération départementale des coopératives d'utilisation de matériel en commun, France
- FEZ, Fédération européenne de zootechnie, Italy
- FNCUMA, Fédération nationale des coopératives d'utilisation de matériel en commun, France
- FOFIFA, Centre national de la recherche appliquée au développement rural, Madagascar
- GRET, Groupe de recherche et d'échanges technologiques, France
- GTZ, Deutsche Gesellschaft für Technische Zusammenarbeit, Germany
- ICCO, International Cocoa Organization, UK
- ICCS, International Cotton Calibration Standards, USA
- IDEFOR, Institut des forêts, Côte d'Ivoire
- IDESSA, Institut des savanes, Côte d'Ivoire
- IFPRI, International Food Policy Research Institute, USA
- IFREMER, Institut français de recherche pour l'exploitation de la mer, France
- IFRPD, Institute of Food Research and Product Development, Thailand
- IICA, Instituto Interamericano de Cooperación para la Agricultura, Costa Rica
- IICT, Instituto de Investigação Científica Tropical, Portugal
- ILCA, International Livestock Center for Africa (now ILRI)
- ILRI, International Livestock Research Institute, Kenya
- INERA, Institut d'études et de recherches agricoles, Burkina
- INGENIC, International Group for Genetic Improvement of Cocoa
- INIBAP, International Network for the Improvement of Banana and Plantain, France
- INIDA, Instituto Nacional de Investigação e Desenvolvimento Agrário, Cape Verde
- INIFAP, Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico
- INRA, Institut national de la recherche agronomique, France
- IPGRI, International Plant Genetic Resources Institute, Italy
- IRA, Institut de la recherche agronomique, Cameroon
- IRAM, Institut de recherches et d'applications des méthodes de développement, France
- IRCT, Institut de recherches du coton et des textiles exotiques, Chad
- IRZV, Institut de recherches zootechniques et vétérinaires, Cameroon
- ISABU, Institut des sciences agronomiques du Burundi, Burundi
- ISRA, Institut sénégalais de recherches agricoles, Senegal
- ITC, International Trypanosomiasis Center, Gambia
- ITCF, Institut technique des céréales et des fourrages, France
- KARI, Kenyan Agricultural Research Institute, Kenya
- KfW, Kreditanstalt für Wiederaufbau, Germany
- KIT, Koninklijk Instituut voor de Tropen, Netherlands
- LNE, Laboratoire national d'essais, France
- NCDP, National Coconut Development Project, Tanzania
- NRI, Natural Resources Institute, UK
- OCLALAV, Organisation commune de lutte antiacridienne et de lutte antiaviaire, Senegal
- ORSTOM, Institut français de recherche scientifique pour le développement en coopération, France
- PCA, Philippines Coconut Authority, Philippines
- PRIAG, Programa Regional de Reforzamiento a la Investigación Agronómica sobre los Granos en Centroamérica, Costa Rica
- PROCELOS, Programme régional de promotion des céréales locales au Sahel, Burkina
- PROMECAFE, Programa Cooperativo Regional para la Protección y Modernización de la Caficultura (IICA), Costa Rica
- QDPI, Queensland Department of Primary Industries, Australia
- REDAFRUTHEX, Red Andina de Frutihorticultura de Exportación
- REDARFIT, Red Andina de Recursos Fitogenéticos
- SAED, Société d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et des vallées du fleuve, Senegal



SEITA, Service d'exploitation industrielle des tabacs et allumettes, France

SICOR, Société ivoirienne de coco râpé, Côte d'Ivoire

SODECOTON, Société de développement du coton, Cameroon

SODEPALM, Société pour le développement et l'exploitation du palmier à huile, Côte d'Ivoire

SONADER, Société nationale de développement rural, Mauritania

SPAAR, Special Program for African Agricultural Research, USA

SPFDP, South Pacific Forestry Development Programme, Fiji

SRI, Silsoe Research Institute, UK

SUAD, Service d'utilité agricole de développement, France

SURAPA, Sub-Red de Areas Protegidas Amazónicas

TIA, Techniques industrielles appliquées, France

TROPIGEN, Network for Amazon Genetic Resources

UAIC, Unité d'afforestation industrielle du Congo, Congo

UAM, Universidad Autónoma Metropolitana, Mexico

UNDP, United Nations Development Programme

UNIDO, United Nations Industrial Development Organization, Switzerland

USAID, United States Agency for International Development, USA

USDA, United States Department of Agriculture, USA

UTFANET, Underutilized Fruit Asian Network, Thailand

VARTC, Vanuatu Agricultural Research and Training Centre

WARDA, West African Rice Development Association, Côte d'Ivoire

WINBAN, Windward Islands Banana Growers' Association, Saint Lucia

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**Centre  
de coopération  
internationale  
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pour le  
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