

# CIRAD 2010







AGRICULTURAL RESEARCH  
FOR DEVELOPMENT

CIRAD is a French research centre working with developing countries to tackle international agricultural and development issues.

With those countries, it works to generate new knowledge, support agricultural development, and contribute to the debate on the main global issues concerning agriculture, food and rural territories.

CIRAD has a global network of partners and regional offices, from which it conducts joint operations with more than 90 countries.

It has a staff of 1800, including 800 researchers. It has an annual budget of 214 million euros, with two thirds provided by the French government.

# Editorial

This 2010 edition of the annual report provides a brief and factual picture of the progress achieved by CIRAD research units in some of the projects carried out under the Centre's main strategic lines of research.

We also hope that it illustrates the diversity of our activities and their impacts on agricultural and rural development in tropical regions.

In addition to showcasing the scientific results and achievements, this report presents a few major events in which CIRAD—a key stakeholder in global agricultural research governance—has been involved. Following the success of GCARD which was hosted in Montpellier in March, the decision to build the future CGIAR headquarters on the same site confirms the global esteem for this foremost agricultural research platform. CIRAD and its teams have been contributing to its dynamics through many collaborations with research and training organizations based in France and other Mediterranean and tropical countries.

During 2010, all of CIRAD's research units were assessed in the AERES 4-year evaluation, which also focused on organizational aspects of the Centre's operations. Note here that CIRAD has been collectively striving to make the most of these assessments and to build—through dialogue—its research structure for the next 4-year term (2011-2014).

Gérard Matheron  
President



# CONTENTS

<b>Editorial</b>	1
<b>Institutional highlights</b>	
CIRAD, a stakeholder in global agricultural research governance	4
Agrimonde, Scenarios and Challenges for Feeding the World in 2050	5
Secure biological resource exchanges	6
INTER-TROP network of biological resources centres	6
Biodiversity at CIRAD: 250 experts, 1/5 of its publications	6
Biotechnology training: CIRAD's commitment with African universities	7
G�rard Matheron is appointed CIRAD President	7
CIRAD's Scientific Council in Cotonou	7
Collective research tools for the scientific community	8
Visacane, the CIRAD sugarcane quarantine service	8
REFUGE, a hosting and training platform	8
Social science research in New Caledonia: a unique 10 year partnership	9
Renewed accreditation of the wood preservation laboratory	9
<b>Research</b>	
<i>Line 1 . Ecological intensification</i>	10
Decoding the cocoa genome	12
Evolutionary history of the shea tree in Sudano-Sahelian Africa	14
Reconstructing meristem growth via cell imaging	15
Ecological intensification in orchards: cover crops to control weeds	16
Nutrient cycles in eucalyptus plantations in Brazil and Congo	17
Regenerating argan tree stands in Morocco	18
<i>Xanthomonas albilineans</i> , a small but sturdy genome	18
Sequencing the genome of two plant trypanosomids	19
Tracking banana weevil movements	20
Tracking greyback cane beetle flights by radiotelemetry	21
Early identification of male tilapia	22
<i>Line 2 . Biomass energy</i>	23
New strategies for catalytic gasification of biomass	24
Charcoal in Madagascar: reconciling urban demand and sustainable management	26
Arina, charcoal in Madagascar	27
Djolibois, a role-playing game for the fuelwood supply chain in Bamako	27
<i>Line 3 . Food</i>	29
The imperfect transmission of world prices to domestic agricultural markets in sub-Saharan Africa	30
Developing markets through innovations: cowpeas in Burkina Faso	32

Evaluating the impact of processing techniques on the nutritional value of foods	32
Supporting the development of food supply chains in West Africa	33
Near-infrared spectroscopy for analysing shea butter	33
A biological barcode for food products	34
First natural waxy cassava starch	35
A reference book on vanilla	35
Preventing and reducing mycotoxin contamination	36
 <i>Line 4 . Animal health and emerging diseases</i>	 37
Liposomes: an innovative system for vaccination	38
Optimizing tsetse fly eradication campaign in West Africa	40
Health ecology and the management of emerging diseases in Zimbabwe	41
Rift Valley fever: what risk for Eurasia?	42
Emerging diseases epidemiology in plants, animals and humans	42
Wildfowl and the transmission of avian influenza in Africa	43
 <i>Line 5 . Public policy</i>	 44
Reinvesting development strategies to adress structural challenges	46
Regulating through standards: standardisation mechanisms sustainable development governance	48
Renewing approaches to innovation: the ISDA 2010 symposium	49
Innovating with the rural actors: action-research partnerships	49
The law of geographical indications: India's experience	50
How do States formulate their sustainable rural development policies?	51
Rural council management, community management and local development	52
 <i>Line 6 . Rural areas</i>	 54
Woody biomass decay in a French Guianan forest	56
When family farming protects the Amazon rainforest	57
Mycorrhizal fungi, partners in the adaptation of plants to their environment	58
Awards for the Biotik software	59
Architectural diagnosis and maturity of French Guianan forests	60
Farmers and the modernisation of irrigation schemes in Tunisia	61
Sharing water resources in the rice-growing region of Klaten, Indonesia	62
The greening of the Sahel: natural vegetation dynamics or land use change?	63
Managing chlordecone pollution in the French West Indies	64
 Indicators	 66
Organization	72
CIRAD worldwide	74

# CONTENTS





# CIRAD, a stakeholder in global agricultural research governance

The restructuring of agricultural research for development has led to a new age of collaborations for CIRAD, which is now striving to take a more active role in global agricultural research governance. It has the resources required to achieve this goal and just launched a series of initiatives through which it intends to make effective use of its expertise and share its values.

## Agreenium, what France has to offer in the agrosience field

The public scientific cooperation consortium Agreenium was set up by CIRAD and five other major organizations in the French agricultural research and higher education field (INRA, AgroParisTech, AgroCampus Ouest, Montpellier SupAgro and the Ecole vétérinaire de Toulouse). This institution aims to internationally promote what France has to jointly and competitively offer on research and training in the fields of agriculture, food, nutrition, animal health and the environment. Within the framework of this institution, CIRAD is focusing especially on promoting agricultural research for development to meet the needs of developing countries and their communities.

## A strategic dialogue with the World Bank

Official development assistance is back in the limelight for agriculture and rural development, especially since the World Bank published the *World Development Report 2008*, recommending greater investment in agriculture to fight hunger and reduce poverty while preserving natural resources. For several years, CIRAD has been conducting research that has revealed novel ways for addressing these global challenges (ecologically intensive agriculture and price volatility), assessing the range of possibilities more effectively (Agrimonde, a foresight exercise conducted in partnership with INRA), and gaining insight into the dynamics involved and their patterns of



© P. Polleco / CIRAD

The last decade led to the emergence of global governance of agricultural research for development, whose principle was laid down in L'Aquila in 2008, during the launching of the Global Partnership for Agriculture and Food Security (GPAFS) under the auspices of the G8 Summit. This governance is underpinned by the multipolarity of decision making centres while encouraging all stakeholders to put forward their opinions.

A decisive step in this process was taken when the first Global Conference on Agricultural Research for Development (GCARD) was held in Montpellier (France) in March 2010. A roadmap was established to facilitate the in-depth transformation of agricultural research

for development, along with the reform of the Consultative Group on International Agricultural Research (CGIAR), the first global targeted research programmes, the revival of the Global Forum on Agricultural Research (GFAR) and the coordination of multilateral and global initiatives. CIRAD was closely involved in organizing this event, in providing GFAR with a senior expert to foster regional consultations, while also contributing human and financial resources for the conference organization.

CIRAD now intends to be a major stakeholder in the planning and implementation of this governance. To this effect, it launched a series of specific initiatives in 2010 in agreement with government authorities.

structural changes in farming systems (Observatory for World Agricultures).

CIRAD, in collaboration with AFD, the French development agency, organized a seminar in Washington in September 2010 to present its work to World Bank experts. This meeting paved the way to a strategic partnership that will strengthen collaborations between the two organizations. Two priorities were outlined. The first consists of five topics: risk management, analysis of changes in agriculture, development engineering, carbon management, and sustainable management of agricultural and forest areas. The second concerns global governance of agricultural research for development within the framework of the action plan agreed by the G20 in Seoul.

### Participating in the development of the first global research programmes

The CGIAR reform, from an institutional perspective, involves the development of a consortium of research centres, with headquarters in Montpellier, and of the international CGIAR Fund overseen by the Fund Council representing Fund donors. Operationally, it is primarily based on global targeted research programmes aimed at reducing poverty, hunger and malnutrition.

CIRAD, along with IRD, is committed to participating effectively in the design, governance and implementation of some of the CG Research Programmes (CRPs)—rice, climate change and agriculture, forests, dryland agriculture, etc.—that will benefit from its recognized scientific expertise. Several CIRAD teams are involved alongside CGIAR centres in designing programmes and identifying their scientific contributions.

### Enhancing CIRAD's clout in United Nations organizations

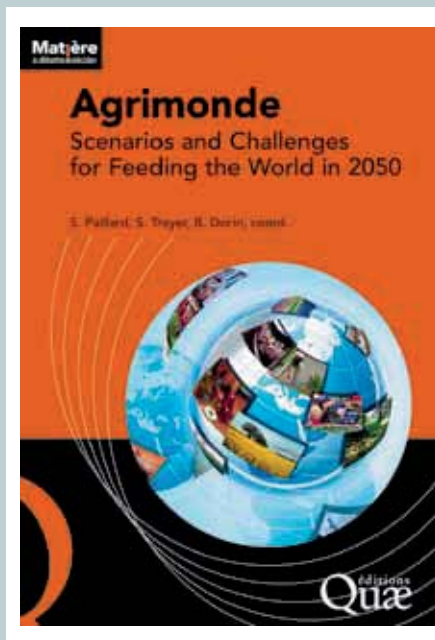
CIRAD intends to increase its presence in Rome in order to strengthen its scientific expertise collaborations with multi-lateral organizations responsible for agriculture and food security. It has thus increased initiatives such as developing a foresight hub, with GFAR, providing support for the FAO World Agriculture Watch (WAW/OAM), while also being involved in research management via this permanent French representation.

Through these initiatives, which are all geared towards greater worldwide visibility, CIRAD will have a more active role in the development of a new global governance of development-oriented agricultural research. ■

CONTACT > Alain Derevier, Rome,  
Office of the Director General in charge  
of Research and Strategy

## Agrimonde, Scenarios and Challenges for Feeding the World in 2050

A three-faceted agriculture and food challenge—food security, environmental conservation and fossil fuel depletion—must be addressed in the 21<sup>st</sup> century. In 2006, INRA and CIRAD thus decided to fulfil this challenge by launching Agrimonde, an initiative to develop a foresight project for analysing issues pertaining to the world's food and agricultural systems within the 2050 time frame. This book sums up the main conclusions of this foresight project and puts forward two potential evolutionary scenarios: first, a trend-based scenario places emphasis on economic growth in a setting in which environmental conservation is not a priority; and the second is based on sustainable development principles with the aim of feeding the world while preserving ecosystems. This book also recapitulates the main statistical references for the 1961–2003 period and describes the Agribiom simulation tool.



Paillard S., Treyer S., Dorin B., 2010. Agrimonde, Scenarios and Challenges for Feeding the World in 2050. Coll. Matière à débattre et décider, Quæ, 296 p. [also published in French]

CONTACT > Bruno Dorin, Montpellier,  
Center for International Research on  
Environment and Development (UMR CIRED)





## INTER-TROP network of biological resources centres

The INTER-TROP project was launched by CIRAD, INRA and IRD and is due to run for 2 years. It brings together tropical plant biological resources centres (BRCs) in a network to ensure plant material quality and conservation. These centres, which have been set up in recent years in France and its overseas departments and territories, host collections that have been compiled through research programmes and survey missions. This plant material serves as a basis for diversification, breeding and diversity analysis programmes. Resource centre management tools and a joint web portal will be developed to facilitate use of the material. This network currently includes five centres: the VATEL centre in Réunion, for vanilla, tropical garlic species and *lontan* (traditional) vegetables; coffee resource centres in Réunion and Montpellier; a rice resource centre in Montpellier; tree plant collections in French Guiana; and a centre for tropical plants from Guadeloupe and Martinique, including pineapple, banana, sugarcane, yam and mango.

CONTACT > Roland Cottin, Montpellier, Tropical Biological Resources Centre



F. Le Bellec / CIRAD

## Biodiversity at CIRAD: 250 experts, 1/5 of its publications

This is the conclusion of an assessment of CIRAD research in this field within the framework of the International Year of Biodiversity. Biodiversity—although not a separate strategic line of research—is naturally a key focus in most of the centre's activities. Over the 2000–2010 period, 2 000 of its scientific publications were directly related to biodiversity, while 250 CIRAD scientists are now biodiversity experts.

# Secure biological resource exchanges

Genetic resource access and management are pivotal to research and development initiatives for developing countries.

The transfer of these resources gives rise to complex specific issues. CIRAD is thus developing ethics, guidelines and methods to ensure, in compliance with international conventions, proper conditions for the management and optimal use of these resources.

Awareness of the fragility of the environment and changes in international laws, which tend to put forward the rights of local communities, has given rise to new issues concerning genetic resource changes over the last 15 years. The Rio Convention on Biological Diversity, which took effect on 29 December 1993, sets down the principle of the sovereignty of States over their genetic resources as well as their obligations with respect to their conservation. It also specifies that there must be fair and equitable conditions of access and sharing of benefits arising from the use of these resources. Many biosafety regulations pertain to the transfer of biological material, especially plants and to an increasing extent animals and microorganisms. These regulations aim to preserve natural and cultivated ecosystems. There are also biosafety issues concerning biotechnologies and invasive species.

CIRAD, as a cooperative research institution, must comply with all biological resource exchange regulations, in addition to striving to preserve biodiversity.

## A code of conduct for genetic resource transfers

CIRAD therefore adopted a code of conduct for genetic resource transfers very early on the basis of studies carried out in the 1990s. In 2001, it published a short guide in French on biological resource transfers, which explains the rules regarding the transfer of biological material, while also serving as a tool to help researchers deal with complex issues that

may arise in their application. It provides references that are especially useful in such an unstable national setting. This practical document, which is also available for non-CIRAD researchers, is still one of the few guides for researchers of scientific organizations and French universities having to cope with biological resource transfer issues.

## Two software packages to determine the status of genetic and biological material

Further to these concerns, CIRAD has developed the Géné-PI software package to facilitate determination of the status of genetic resources and the most suitable type of Biological Material Transfer Agreement (MTA) for this status. At the request of FAO, it recently developed Gene-IT, an international version of this software that is tailored for implementation of the 2001 International Treaty on Plant Genetic Resources for Food and Agriculture. This program helps users draw up standard MTAs and follow-up biological plant material exchanges—several language versions are available.

The short guide on biological resource transfers and the Géné-PI software package are regularly updated and the latest versions will be published in 2011. ■

CONTACT > Philippe Feldmann, Montpellier, Biological Resource Committee



## Gérard Matheron is appointed CIRAD President

On 30 June 2010, Gérard Matheron, Director General of CIRAD since 2006, was appointed CIRAD President at a cabinet meeting. He was assigned



© M. Adell / CIRAD

this dual role within CIRAD's new organizational structure in which the functions of President and Director General have been merged.

## CIRAD's Scientific Council in Cotonou

For the second time in 2 years, a CIRAD Scientific Council meeting was held in Africa. Focused on issues concerning partnerships, which are pivotal to CIRAD's strategy, this session was held in Cotonou, Benin, from 27 to 29 May 2010, back to back with the General Assembly of the West and Central African Council for Agricultural Research and Development (CORAF/WE CARD). Partnership is also a priority under the new mandate of CIRAD's Scientific Council, chaired by sociologist Bertrand Hervieu.

CIRAD's Scientific Council, which reports to the Director General, is consulted on the contents and conditions for organizing and conducting research and study programmes. It puts forward proposals concerning CIRAD's research targets and main strategies for recruitment, training, partnership and geographic extension.

CONTACT > Jean-Louis Sarah, Montpellier, Office of the Director General in charge of Research and Strategy



## Biotechnology training: CIRAD's commitment with African universities

CIRAD continues to promote the development of university collaborations that give rise to new intervention approaches, particularly through the use of new distance training technology. Two plant biotechnology courses, designed in collaboration with West African universities and French institutions, highlight CIRAD's commitment in this area.

### Biotechnology training in Africa

Biotechnology is now essential for breeders, but biotechnology training is still sparse in developing countries due to the lack of resources. Since 2007, CIRAD has thus been supporting the SudBiotech initiative through which two annual plant biotechnology workshops have already been organized at the University of Ouagadougou and the University of Cotonou. Based on a multidisciplinary programme, this training includes different aspects of biotechnologies, and tailoring them specifically for use by communities in developing countries. The aim is to train students, researchers, policy makers and professional stakeholders on these techniques, while focusing specifically on the practical aspects in order to facilitate their appropriation. The programme includes 60 h of courses and hands-on laboratory work, taught by teacher-researchers with complementary skills, in addition to a session to prepare researchers for an international career. Finally, the teaching materials produced under the SudBiotech initiative are handed over to the partner institutions to enhance plant science courses taught by their staff. The project will be ongoing, with the development of an educational plant biotechnology introduction toolkit, including audiovisual course support material and equipment required for conducting basic biochemistry and molecular biology experiments.

CONTACT > Alain Rival, Montpellier, Crop Diversity, Adaptation and Development (UMR DIADE)

**Partners >** Agence universitaire de la francophonie (AUF), University of Paris-Sud, Centre national de la recherche scientifique (CNRS), Abomey-Calavi University (Benin)

Rival A. et al., 2010. Sudbiotech-Bénin: un module de formation intégrée en biotechnologie végétale. In: XII<sup>es</sup> Journées scientifiques du réseau Bioveg, AUF, Cluj-Napca, Romania, September 2010

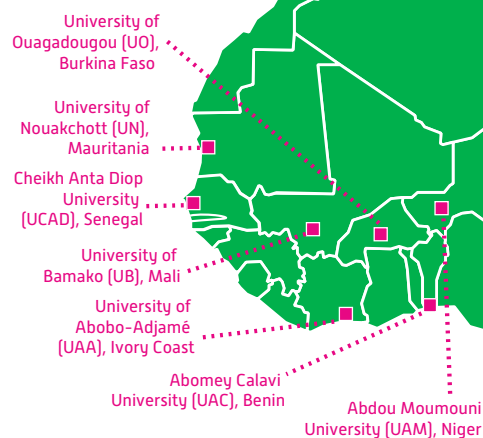
### CIRAD, a partner in an international tropical biotechnology Master's programme

MIBioT (international Master's programme on tropical biotechnology) is a unique initiative. It offers high quality e-learning courses using specific training tools while tapping the biotechnology and biosafety expertise of all the West African and French training partners. Seven African universities and four French partners—CIRAD, IRD, University of Montpellier 2 and Montpellier SupAgro—are involved.

Each university, as well as all other educational institutions, awards a diploma displaying the MIBioT label. Through the open and remote training process and due to the emphasis placed on the collective learning phases, MIBioT is a structuring project in a joint geographic, economic and scientific partnership. This Master's programme supplements the educational packages offered by the participating universities, in addition to enhancing the training offered in this field worldwide.

CONTACT > Nadine Zakhia, Higher Education and Training Service

Seven West African universities participating in the MIBioT Master's programme.



## Collective research tools for the scientific community

CIRAD and its partners rely on increasingly sophisticated equipment and infrastructures, collections of rare biological resources, and long-term monitoring and testing approaches in order to facilitate and obtain the best results in research projects. As these research tools are expensive and require highly specialized technical staff, they are often shared in open facilities.

CIRAD is participating in a national and European strategy to promote the development of collective research infrastructures, which enables the scientific community to have access to unique top notch biological, scientific and technical resources. Through CIRAD, these collective tools may be used by partners in developing countries within the framework of projects and training courses.

These research infrastructures are collectively funded and managed within scientific platforms, biological resource centres and in-situ monitoring and research systems. They can, depending on their scope and structure, be recognized, labelled and benefit from regional and even national support. The IBISA label, for instance, acknowledges the national merit of a life science platform or a biological resource centre, while the SOERE label is attributed by ALLENI, the French *Alliance nationale pour la recherche sur l'environnement aux systèmes d'observation et d'expérimentation pour la recherche sur l'environnement*. Several infrastructures managed by CIRAD have obtained these labels, including a plant research platform in

Réunion, a plant histocytology and imaging platform in Montpellier, three tropical biological resource centres in the West Indies, Montpellier and Réunion, and GUYAFOR, an environmental research observatory.

These collective research tools, which have been pooled and are supported by the Office of the Director General, should be developed in the coming years in France and its overseas departments and territories, while gradually encompassing priority structures in other countries worldwide.

CONTACT > Cathy Grevesse, Montpellier, Office of the Director General in charge of Research and Strategy

### Visacane, the CIRAD sugarcane quarantine service

As sugarcane is generally propagated by cuttings, there is a high risk of propagating pathogens and pests when the material is transported from one site to another. In the 1970s, CIRAD set up a sugarcane quarantine service to curb risks during exchanges



© T. Erwin / CIRAD

between growing countries. This quarantine service is located in Montpellier, far from any sugarcane production areas, and is part of a plant pathology joint research unit that studies variability in pathogens and the emergence of new diseases. Plant varieties are monitored over two crop cycles, while focusing specifically on detecting the possible presence of pathogens and on eliminating them. This quarantine service—recently named Visacane—now supplies disease-free varieties to growers and breeding centres worldwide. It also enables research centres to exchange germplasm under excellent phytosanitary conditions. It ensures compliance with the intellectual property rights of breeders of the received and disseminated plant

material. Over 4 000 sugarcane varieties have now passed through Visacane in Montpellier.

CONTACT > Jean-Claude Girard, Isabelle Guinet, Montpellier, Biology and Genetics of Plant-Pathogen Interactions (UMR BGPI)

<http://visacane.cirad.fr/en/>

### REFUGE, a hosting and training platform

REFUGE is an international researcher hosting platform where scientists from different fields can determine the functions of the genes they are studying based on the rice system model. This platform was founded to provide these scientists with access to the rice functional genom-

ics expertise and resources available in Montpellier. REFUGE, which is funded by Agropolis Fondation, offers extended professional training and hosting to researchers, technicians and students whose research it supervises. The aim is, especially for scientists in developing countries, to supplement their research so as to enhance their potential for publishing in top ranking publications and their effectiveness in addressing regional and international calls for proposals.

CONTACT > Delphine Mieulet, Montpellier, Genetic Improvement and Adaptation of Mediterranean and Tropical Plants (UMR AGAP)

[www.refuge-platform.org](http://www.refuge-platform.org)



© D. Mieulet / CIRAD



## Social science research in New Caledonia: a unique 10 year partnership

New Caledonia has, since 1988, been involved in a negotiated decolonization process in which research has a key role. The country thus set up an agricultural research institute (IAC) in 2000, with CIRAD as a strategic partner. Over the last 10 years, CIRAD and IAC have been developing research on rural household strategies, on links between mining and agricultural activities, as well as on the original public policies that have been implemented in this emancipation process.



Farmer in a seed garden set up to preserve Tiouande clones belonging to the Tiwaé tribe © C. Gaillard/IAC

In terms of research, the provisions of the French Organic Law N° 99-209 of 1999 (Article 4) stipulate that the government “is consulted on contracts between the State and research organizations set up in New Caledonia [and] can enter into a general agreement of objectives with these organizations.” IAC, the New Caledonian agricultural research institute, is a public establishment that is managed and funded by the new local authorities and the State. It was founded in 2000 with the aim of conducting targeted research for agricultural and rural development and participating in the training of scientists. A framework agreement outlines these partnerships and specifies that CIRAD will provide scientific support.

In social sciences, CIRAD is participating in a research programme on rural systems and grassroots development which, since 2006, has been reoriented to focus more specifically on the analysis of public policies related to rural life. The team, consisting of local and expatriate researchers based in the northern province of New Caledonia, conducts assessments on grassroots development and public policies. It also carries out targeted research on the impact of mining activities on rural life, on non-commercial aspects of development and on the analysis of public actions, while also participating in the agriculture and sustainable development programme of the French research agency (ANR). It offers training courses as part of a professional

Master's programme in collaboration with the University of New Caledonia.

The external committee that has evaluated IAC's work three times drew attention to the relevance of the programme and its academic recognition, as well as its contribution to local discussions on the future of rural life, and more generally on alternative development models during the emancipation process. IAC and CIRAD

are also to be involved in major surveys in 2011 and 2012 to depict the agricultural transition under way in New Caledonia.

**CONTACT >** Jean-Michel Sourisseau, Montpellier, Actors, Resources and Territories in Development (UMR ART-Dev)

**Partner >** Institut agronomique néo-calédonien (IAC)

Sourisseau J.M. et al., 2010. A la recherche des politiques rurales en Nouvelle-Calédonie : trajectoires des institutions et représentations locales des enjeux de développement [1853-2004]. IAC éditions, Etudes et synthèses, 120 p.

## Renewed accreditation of the wood preservation laboratory

The CIRAD wood preservation laboratory had its accreditation renewed by COFRAC in 2010 for tests on the durability of wood and

wood-based products and on the protective efficacy of wood preservatives and termite control products.

The quality approach adopted by the wood preservation laboratory is reflected by the type of tests that are carried out as part of research projects or at the request of private operators. Tests to determine the resistance against wood-destroying biological agents are the most difficult of all wood analysis tests. They are aimed at assessing and quantifying the impact of living organisms, such as fungi and termites, on a lignocellulosic material. The extent of variability of this impact, which in turn is linked with the diversity of these organisms and of the material, can be readily determined. The validity and reliability of the findings therefore depend directly on the quality of the experimental approach and on the careful compliance with the standardized testing.

In September 2010, COFRAC, the French accreditation committee, renewed the laboratory's accreditation (no. 1-1686) according to the standard to which testing and calibration laboratories must comply (ISO 17025). This accreditation pertains to eight tests on the durability of wood and wood-based products and on the protective efficacy of wood preservatives and termite control products.

The wood preservation laboratory is the first CIRAD laboratory to be accredited (in 2006), and its expertise is now recognized by the international scientific community and professional stakeholders in this sector. This accreditation is a firm guarantee of the laboratory's expertise for research partners wishing to take advantage of this expertise or to respond to calls for tenders for European projects.

Finally, the quality approach is a long-term process involving continuous improvement of practices and regular broadening of the scope of application. Extension of this approach to other standardized tests and the development of new methods are planned for the next accreditation cycle so as to take advantage of the experience already acquired in the development and adaptation of experimental methods and prenormative research.

**CONTACT >** Luc Martin, Montpellier, Production and Processing of Tropical Woods (UPR)



A farm in Peru  
© P. Sist/CIRAD

## line 1 \ **ecological intensification**

Helping to invent  
ecologically intensive  
agriculture  
to feed the world



## AGREEMENTS, PARTNERSHIPS

**Global Rice Scientific Partnership:** CIRAD and IRD researchers are participating in the first CGIAR Mega Programme that was officially launched on 10 November at the 3<sup>rd</sup> International Rice Congress.

**The Yunnan Academy of Agricultural Sciences (China)** and CIRAD have renewed a general collaboration agreement that has been under way for over 10 years concerning rice and sugarcane research—agroecology is a key feature in this renewal.

**In Indonesia,** CIRAD signed an agreement for a new 5-year cooperation programme with the Indonesian Agency for Agricultural Research and Development (IAARD), focused on food security, ecological intensification and training.

**In Brazil, the first rice hybrid** developed through a CIRAD-EMBRAPA collaboration is now being marketed. Cost-effective production of seeds of this high-quality irrigated rice hybrid has benefitted from several innovations.

## EVENTS, CONFERENCES

**The Paris International Agricultural Show** in March provided an opportunity for CIRAD to present the ecological intensification issue. In addition to the many documents published and a stand, two round tables were organized on the topic: Is ecologically intensive agriculture a utopian concept?

**Agro2010, the first international scientific week on agronomy,** organized by the European Society for Agronomy, was held in September in Montpellier. It focused especially on the ecological intensification topic. The event was supported by Agropolis Fondation and many scientific and other partners based in France.

**Ecologie 2010, the first national conference on scientific ecology,** was held in September in Montpellier. CIRAD jointly organized two sessions: one on spatiotemporal hierarchical models, and the other on the ecological and socioeconomic impacts of species introductions.

**ODEADOM,** the Office pour le développement de l'économie agricole d'outre-mer, and CIRAD assessed the state of the banana market in June. The **Planète mode d'emploi** show, held in December in Paris, provided an opportunity for CIRAD and the Union des groupements de producteurs de bananes de Guadeloupe et Martinique to showcase research that has been conducted on the banana industry in the West Indies. **ACORBAT, the Association for Cooperation on Research and Comprehensive Musaceas** (Banana and Plantain) Development, in which CIRAD is an active member, held its 19<sup>th</sup> International Meeting in Colombia, in

2010. This event was closely followed by the entire banana industry.

**Oil palm and sustainable development:** a special edition of the journal *Oléagineux Corps gras Lipides* (November–December 2010), of which CIRAD is a partner, sheds light on this issue. CIRAD also jointly organized the second International Conference on Oil Palm and Environment, **ICOPE 2010**, which was held in February in Indonesia. In addition, an International Symposium on the Biology of the Palm Family, **PALMS 2010**, was hosted in Montpellier by CIRAD and IRD, with the support of Agropolis Fondation, the Languedoc-Roussillon regional council and Montpellier district council.

**The Guide de production intégrée des mangues à la Réunion** is a handbook on integrated mango production containing information acquired through a project on the mango supply chain in Réunion: changes in mango production standards, local to international aspects of the mango supply chain, mango tree functioning and cropping, and postharvest mango fruit preservation.

**The future of natural rubber,** and especially of its sources, was discussed at a meeting organized by the EU-Pearls consortium (Production and exploitation of alternative rubber and latex sources) and CIRAD that was held in October in Montpellier.

**ASIC,** the Association for Science and Information on Coffee, of which CIRAD is a member, held its 23<sup>rd</sup> Conference in Indonesia in October. It was organized by ICCRI, the Indonesian Coffee and Cocoa Research Institute. The two topics covered were: coffee consumption and human

health; and climate change and sustainable coffee production.

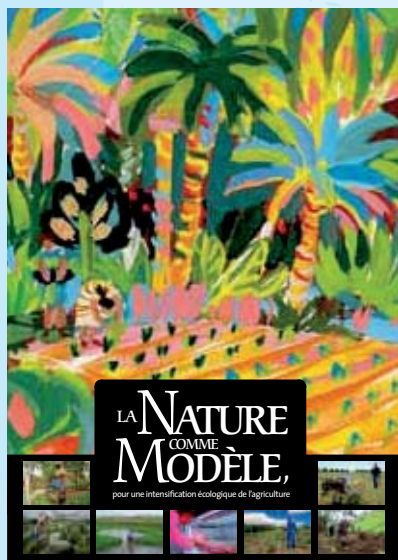
**Innovative animal production in a changing world** was the topic of the SAPT 2010 Sustainable Animal Production in the Tropics conference, jointly organized by CIRAD, that was held in November in Guadeloupe.

**The 13<sup>th</sup> European Poultry Conference** was held at Tours in August. It was organized by the French branch of the World Poultry Science Association (WPSA) with the support of AFSSA, CIRAD, FAO, INRA and ITAVI.

The first seminar on **bioinformatics in genetics**, organized by the Consortium international en biologie avancée (CIBA), a CIRAD priority research platform in partnership in Brazil, was held in November in Brazil.

**The European ENDURE Network of Excellence**, Diversifying Crop Protection, presented its results to all IPM stakeholders during a wrap-up conference in Paris, in November. Anyone interested can download the report from the ENDURE website.

**Plant pathogenic bacteria** were the focus of the International ICCPB 2010 Conference held in June in Réunion, it was organized by CIRAD, INRA, IRD and the University of Réunion.



# Decoding the cocoa genome

*An international consortium of around 60 partners, coordinated by CIRAD, has just sequenced the genome of the Criollo cocoa variety originally collected in Belize. This progress will speed up studies on cocoa and its improvement, with the aim of generating new high-yielding, disease resistant varieties with excellent flavour qualities.*



Cocoa seedlings  
© C. Lanaud/CIRAD

**T**he International Cocoa Genome Sequencing Consortium (ICGS) has thoroughly sequenced and analysed the genome of the cocoa tree, *Theobroma cacao*. This sequencing concerned the Criollo cocoa variety that was collected in Belize, and which is thought to be a descendant of the first ancestral cocoa trees that were domesticated by the Mayan civilization 2 000 years ago and from which excellent quality chocolate is produced.

## A sequence representing 87% of the genome

Several new generation sequencing techniques were combined

to produce a high quality sequence assembly consisting of 28 798 genes encoding proteins and pooling 98% of the genes expressed in cocoa. This assembly now corresponds to 87% of the total 430 Mb genome. A very high density genetic map containing 1259 markers was constructed to align the sequence assembly and reconstruct the chromosome sequences, and 75% of the genome was thus anchored.

Initial analyses of this genome were focused on a few gene families potentially involved in two features that are essential in cocoa breeding—chocolate quality and disease resistance.

## Preserving chocolate quality

Chocolate quality is the result of a complex process involving several classes of biochemical compounds, including polyphenols which have a crucial role. Analysis of the cocoa sequence revealed 96 genes involved in the biosynthesis of these compounds, including a gene family that is especially highly represented in cocoa in comparison to other species.

An analysis of genes involved in the biosynthesis of cocoa butter, which accounts for around 50% of the dry weight of cocoa beans, and terpenes, which are responsible for

CONTACT >  
Claire Lanaud,  
Xavier Argout,  
Montpellier,  
Genetic  
Improvement  
and Adaptation  
of Mediterranean  
and Tropical  
Plants  
(UMR AGAP)



many aromatic flavours, is further evidence of the extension of specific families of genes, such as those encoding linalool. These genes could have a key role in the technological and aromatic properties of chocolate.

## Identifying disease resistance genes

Fungal diseases have an especially devastating impact on cocoa production and are responsible for around 30% of cocoa harvest losses. Hence, one of the main goals of breeders is to achieve sustainable resistance.

A detailed analysis of two of the main known resistance gene families in plants has already led to the identification of genes potentially involved in cocoa fungal disease resistance mechanisms. These will soon be the focus of more in-depth studies.

The analysis of this sequence also provided evidence of the evolutionary history of cocoa trees whose genome, like that of grapevine, is very close to the common ancestor of dicots. Cocoa could thus serve as a simple new model for studying evolutionary processes. ■

Argout X. et al., 2011. The genome of *Theobroma cacao*. *Nature Genetics*, 43: 101-108. Doi: 10.1038/ng.736

The International Cocoa Genome Sequencing Consortium is coordinated by CIRAD and includes scientist members from around 20 institutions in six countries (France, USA, Ivory Coast, Brazil, Venezuela, Trinidad and Tobago). It is funded by several public and private institutions in France [CIRAD, Agropolis Fondation, Valrhona, Région Languedoc-Roussillon, ANR], as well as in the United States and Venezuela.

Total cocoa genome sequences have been deposited in the EMBL Nucleotide Sequence Database and in the DDBJ database under accession numbers CACC01000001 to CACC01025912 (<http://cocoagendb.CIRAD.fr>).

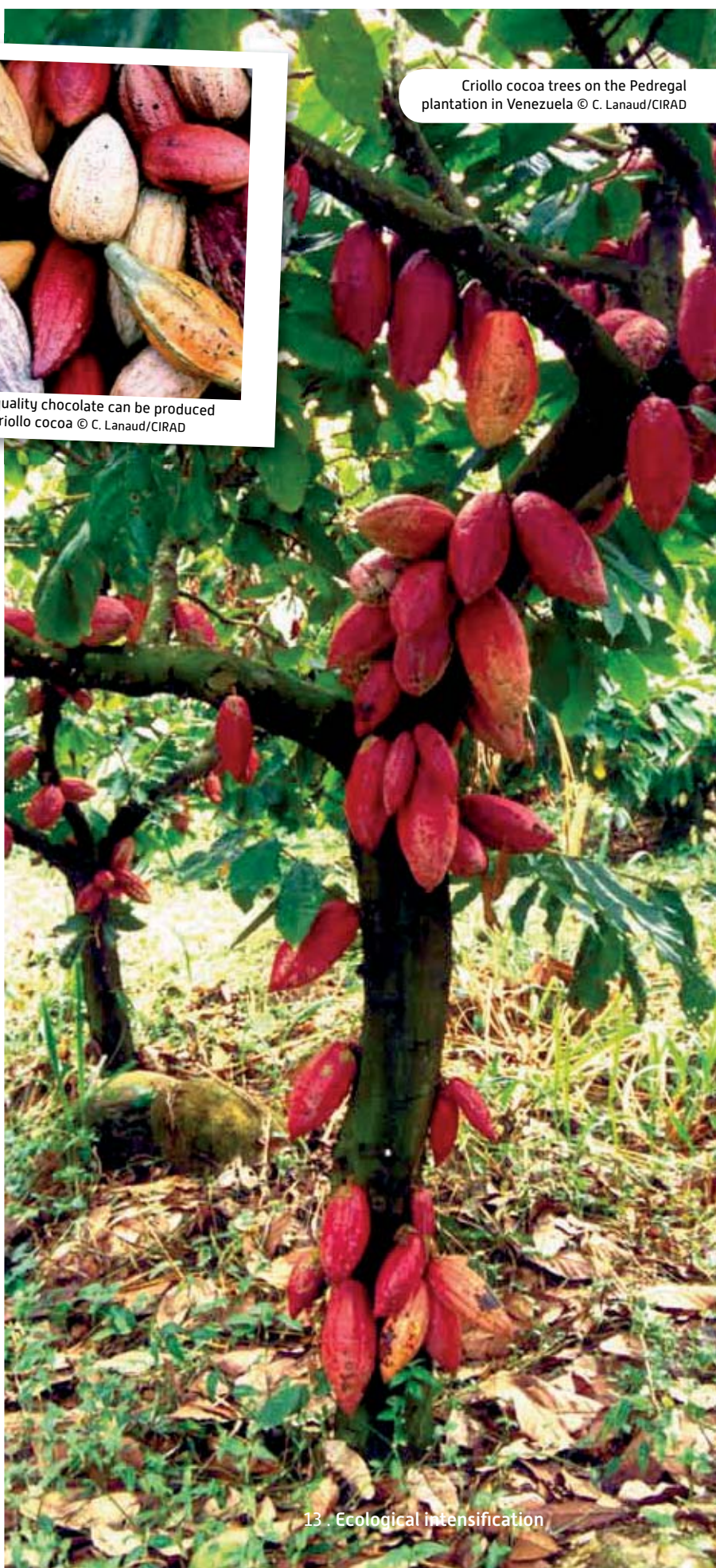


Excellent quality chocolate can be produced from Criollo cocoa © C. Lanaud/CIRAD

### Partners >

Commissariat à l'énergie atomique (Genoscope, CNG-CEA), Institut national de la recherche agronomique (INRA), Centre national de la recherche scientifique (CNRS), Universities of Evry and Perpignan, Valrhona, Penn State University (USA), University of Arizona (USA), Cold Spring Harbor Laboratory (USA), Centre national de la recherche agronomique (CNRA, Ivory Coast), Comissão Executiva de Planejamento da Lavoura Cacaueira (CEPLAC, Brazil), Centro Nacional de Biotecnología Agrícola (Venezuela), University of West Indies (Trinidad and Tobago)

Criollo cocoa trees on the Pedregal plantation in Venezuela © C. Lanaud/CIRAD





# Evolutionary history of the shea tree in Sudano-Sahelian Africa

*Shea is a fruit tree of Sudano-Sahelian Africa. Shea 'butter' extracted from its seeds is a major source of fat and represents a major development opportunity for this region. CIRAD and its African partners have launched a large-scale study on shea diversity and domestication with the aim of enhancing the preservation and use of this species. A combined genetic and chemical analysis generated a first picture of its history.*

**S**hea (*Vitellaria paradoxa*) has been utilized in West Africa for almost 3 000 years. Studies based on the morphological traits of shea stands in this region suggest that this tree was first semi-domesticated on Mossi plain in Burkina Faso. Its diversity and domestication have just been analysed using neutral molecular markers and by studying the variability of chemical constituents of shea seeds and genes involved in their biosynthesis.

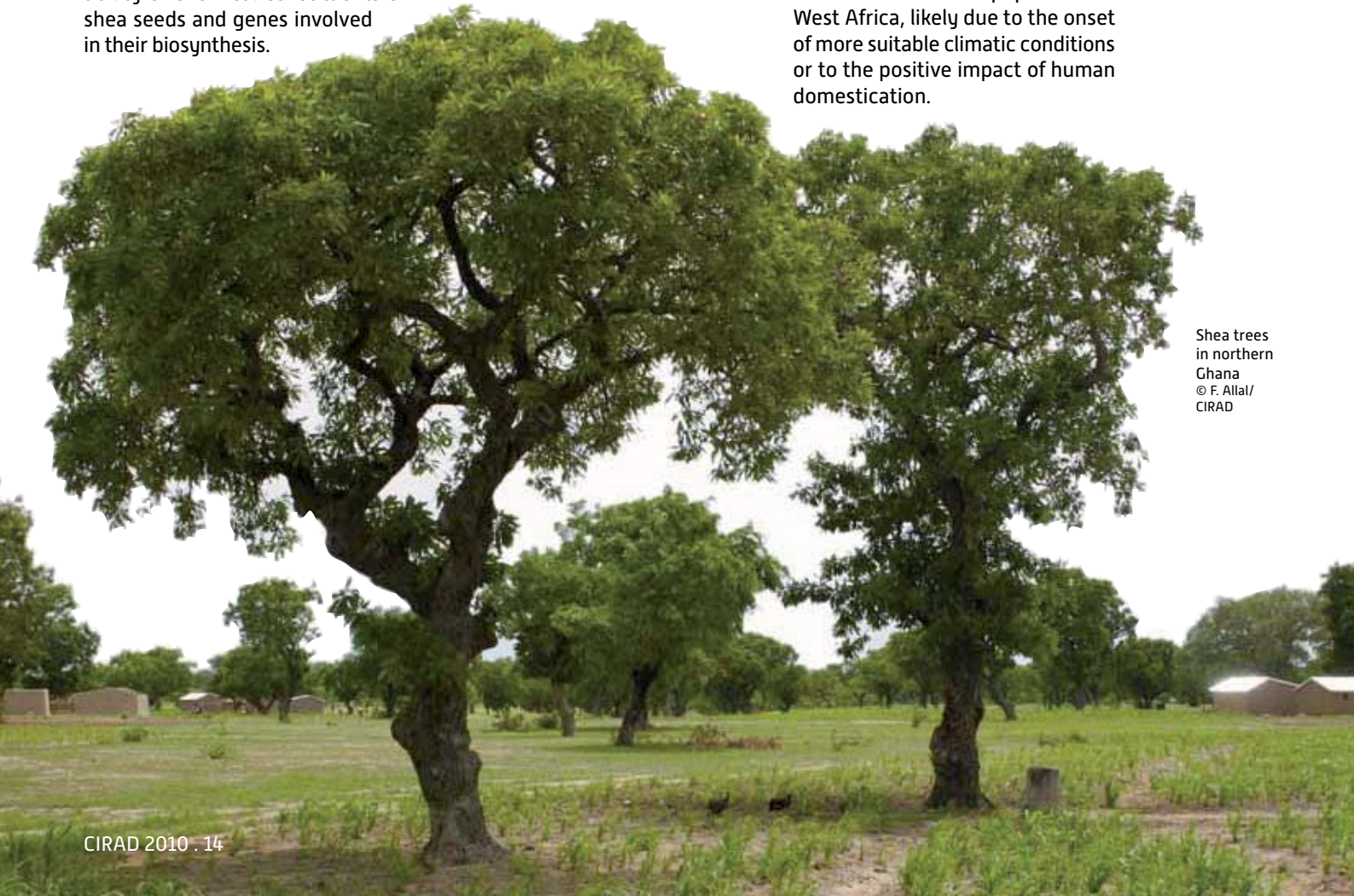
## Migration, glacial refugia and stand expansion

Neutral molecular marker findings indicate that shea is native to West Africa, from where it subsequently migrated into East Africa. These findings also highlighted three genetic groups corresponding to sub-Saharan West, Central and East

African types. Modelling of shea distribution ranges in the Last Glacial Maximum, 20 000 years ago, shed light on how these groups diverged. At that time, the distribution range of this species was continuous throughout West Africa, whereas it was fragmented around Lake Chad and in northern Uganda. Coalescence simulation of the evolutionary scenarios revealed an increase in the shea population in West Africa, likely due to the onset of more suitable climatic conditions or to the positive impact of human domestication.

CONTACT >  
François Allal,  
Pointe-Noire,  
Genetic  
Improvement  
and Adaptation  
of Mediterranean  
and Tropical  
Plants  
(UMR AGAP)

Shea trees  
in northern  
Ghana  
© F. Allal/  
CIRAD





## Chemical variations in seeds and gene polymorphism

An analysis of the fatty acid composition of shea seeds revealed significant differences between genetic groups: shea seeds from West Africa have a higher stearic acid [saturated fatty acid] content and produce solid butter at ambient temperature; seeds from East African shea trees have a high oleic acid [unsaturated fatty acid] content and produce liquid fat. An analysis of polymorphism in the SAD (stearoyl-ACP-desaturase) gene, which encodes the key enzyme in the transformation of stearic acid into oleic acid, revealed a gene duplication in shea. For shea from East Africa, this duplication leads to the production of two functional SAD proteins. Conversely, in shea from West Africa, one of the two SAD genes has a mutation,



Ripe shea fruit, Ghana © F. Allal/CIRAD

resulting in the formation of a truncated nonfunctional protein. This finding could explain the chemical differences between shea from different regions, while the neutral marker data seem to indicate that the evolutionary divergence between groups was the result of genetic drift. However, the polymorphism study of SAD genes sug-

gested that individuals in West Africa bearing the defective gene could have been favoured by natural selection in response to the environmental constraints of the region. Finally, the butter hardness trait, thus with a high stearic acid content, was selected by humans during the shea domestication process in West Africa. ■

**Partners >**  
Institut d'économie rurale (IER, Mali), Makerere University (Uganda), Institut de l'environnement et des recherches agricoles (INERA, Burkina Faso), Institut sénégalais de recherches agricoles (ISRA, Senegal), University for Development Studies (Ghana)

Allal F. et al., 2010. Past climate changes explain the phylogeography of *Vitellaria paradoxa* over Africa. *Heredity* [in press]

## Reconstructing meristem growth via cell imaging

Two CIRAD teams and their partners have just shown that it is possible to automate the recognition of meristem cells—a group of cells that generate all plant organs—in 3D and to track their division and growth over time using laser microscopy and suitable algorithms. This work, which was carried out as part of a study on plant meristem tissue growth, combined cell imaging and mathematical image processing. It is a substantial advance that will benefit the biology community overall because it overcomes a major stumbling block to the understanding of the development of plant organisms and the role of the cell component in growth and acquisition of the final form of organs. There are many potential applications for this new method, especially for studying how the

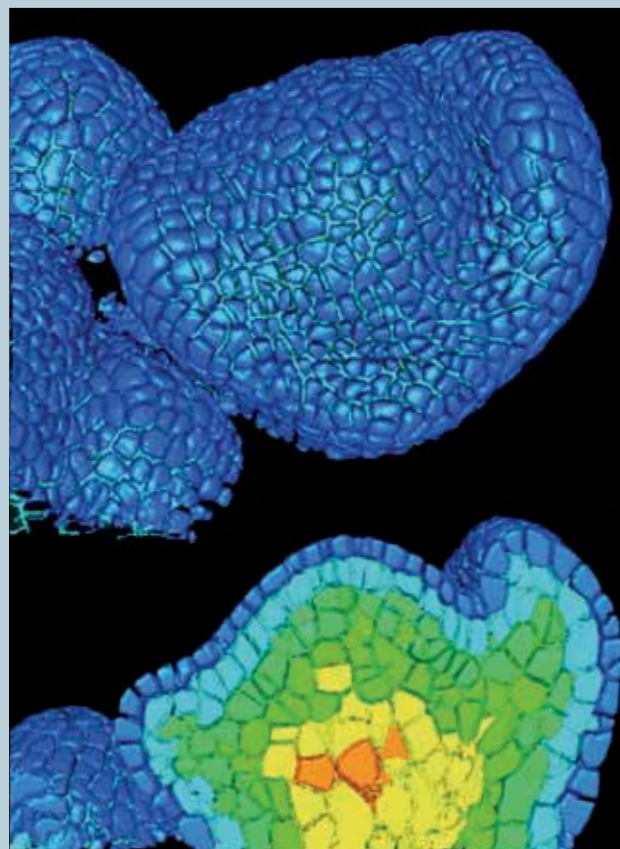
environment and genetics influence plant development.

**CONTACT >** Christophe Godin, Montpellier, Genetic Improvement and Adaptation of Mediterranean and Tropical Plants (UMR AGAP)

**Partners >** Ecole nationale supérieure de Lyon (ENS-Lyon), Institut national de recherche en informatique et automatique (INRIA), Institut national de la recherche agronomique (INRA), Région Languedoc-Roussillon, Agence nationale de la recherche (ANR)

Fernandez R. et al., 2010. Imaging plant growth in 4D: Robust tissue reconstruction and lineaging at cell resolution. *Nature Methods*, 7: 547–553.

Digital 3D reconstruction of a floral meristem (*Arabidopsis thaliana*) using confocal microscopy. Cells were automatically segmented using a series of algorithms. The bottom image shows a segmentation within meristem tissues, highlighting the different cell layers in false colours



# Ecological intensification in orchards: cover crops to control weeds

*In humid tropical regions such as Martinique, weed control is essential in orchards but hard to manage without herbicide treatments, especially in areas where mechanized cultivation is unfeasible and labour is expensive. Sowing cover crops in orchards has turned out to be an interesting solution. As part of an agroecological approach, a CIRAD team has just developed a method for identifying the most suitable cover crops for citrus orchards in Martinique.*

Reducing pesticide treatments is a current priority in intensive cropping systems in both tropical and temperate regions. Reintroducing biodiversity in monocropping systems can enhance biological control, reduce or eliminate the need for chemical inputs, while curbing erosion and runoff. Based on this hypothesis, CIRAD launched a study to identify the best cover crops for controlling weeds in citrus orchards in Martinique.

## Composite picture of an ideal cover crop

A multicriteria assessment grid was developed to pinpoint ideal cover crops. The species characteristics were all predefined according to climatic conditions, risks of introducing potentially invasive species and the commercial availability of seeds. Other features were then determined on the basis of the expected agronomic and ecological services: ability to control weeds, low competition with the main crop for water and nutrients, a potential positive impact on nutrition, and the host status with respect to pests and beneficials. From a functional standpoint, the cover crop is also integrated in the cropping system and should be able to quickly cover the soil while not producing much biomass.

## Single plant species or mixtures

This grid was used to detect a small number of adapted plants: grasses, such as *Urochloa mozambicensis* and three *Paspalum* species, as well as nonclimbing legumes that grow naturally in Martinique, such as *Alysicarpus vaginalis*, *Desmodium barbatum* and *D. triflorum*.

The multicriteria assessment grid was designed as a generic tool that can be readily tailored to different cropping systems. It would, however, be hard to find plants that combine all of the required charac-

### Partners >

Universidad de Ciego de Avila (UNICA, Cuba), Instituto de Investigaciones en Fruticultura Tropical (IIFT, Cuba), Fédération régionale de défense contre les organismes nuisibles de la Martinique (FREDON), Station d'essais en cultures irriguées (SECI, Martinique)

Mandarin orchards  
© F. Le Bellec/CIRAD

teristics, and studies are now being focused on mixtures of species whose functional traits are pooled in a composite grass cover. ■

CONTACT > Christian Lavigne, Le Lamentin, Martinique, Agroecological Functioning and Performances of Horticultural Cropping Systems (UPR HortSys)

Lesueur-Jannoyer M., Le Bellec F., Lavigne C., Achard R., Malézieux E., 2010. Choosing cover crops to enhance ecological services in orchards: a multiple criteria and systemic approach applied to tropical areas. *Procedia Environmental Sciences* (in press)





# Nutrient cycles in eucalyptus plantations in Brazil and Congo

*Most commercial eucalyptus plantations in Brazil produce around twice as much timber as those in the Congo. This situation could be explained by differences in climate, soil and silvicultural practices. The main processes underlying the production of these plantations were identified by quantifying nutrient fluxes during a complete rotation. These results could have important implications for the fertilization of tropical eucalyptus plantations.*

Around 25 m<sup>3</sup>/ha/year of timber is produced in commercial eucalyptus plantations in the Congo, whereas the productivity is twofold higher in Brazil. CIRAD is conducting biogeochemical and ecophysiological studies in these two countries to identify the factors responsible for these variations.

## Nitrogen, the main limiting factor in Congo

This wide discrepancy in production levels could be explained by the sharp differences in climate, soil and silviculture conditions in these two countries. In the Congo, the climate is less suitable, with a marked dry season and relatively low incident radiation, the soil is sandier and silviculture is less intensive.

Nutrient fluxes were monitored over a complete rotation in both situations so as to assess the impact of nutrient inputs on the functioning of the plantations. In the Congo, the biogeochemical patterns differed in the original savanna areas and in eucalyptus plantations, but the input-output budgets of nutrients in soils were found to be close to equilibrium in both ecosystems, apart from the nitrogen budget in eucalyptus plantations. This latter imbalance is due to the fact that high levels of nitrogen are exported with the biomass, and the loss is not offset by sufficient fertilization. This

situation accounts for a deficit of around 100 kg/ha of nitrogen per rotation, which could undermine the sustainability of eucalyptus plantations in the Congo.

## Reducing fertilization

There was very little nutrient loss via deep drainage throughout the rotation cycle, and the level was lower than the atmospheric input in both of the studied situations. In eucalyptus plantations, the vertical below-ground and above-ground growth rates were in the same range, thus enabling trees to tap water stored in deep soil layers following clearcutting. The results also showed that eucalyptus trees responded positively to sodium inputs when soil potassium levels were very low. This phenomenon is of considerable economic interest and could enable operators to reduce their potassium fertilization expenditures.

The introduction of fast-growing legume trees in these plantations is also planned to reduce nitrogen fertilizer inputs and stabilize or even increase production through successive rotations. In 2004, a network of experimental stands was set up at five sites in Brazil and the Congo to assess the behaviour of single-species and mixed eucalyptus and nitrogen-fixing acacia stands under a wide range of climatic conditions and soil types. Nitrogen and phosphorus availabilities in the soils dif-



Rainfall exclusion in a *Eucalyptus* fertilization experiment in Brazil © J.P. Laclau/CIRAD

fered at the study sites, and eucalyptus growth was markedly hampered by the lack of nitrogen in the Congo and of phosphorus in Brazil. Isotopic measurements showed that symbiotic nitrogen fixation fulfilled around 60% of nitrogen requirements of acacia trees planted in mixed stands with eucalyptus in Brazil, and over 90% in the Congo. Further studies have started in Brazil to assess interactions between water and nutrient supplies on the functioning of these plantations. ■

CONTACT > Jean-Paul Laclau, São Paulo, Functional Ecology and Biochemistry of Soils and Agroecosystems [UMR Eco&Sols]

Laclau J.P. et al., 2010. Biogeochemical cycles of nutrients in tropical *Eucalyptus* plantations: Main features shown by intensive monitoring in Congo and Brazil. *Forest Ecology and Management*, 259: 1771-1785.

**Partners >** Centre de recherche sur la durabilité et la productivité des plantations industrielles (CRDPI, Congo), University of São Paulo (Brazil), Institut national de la recherche agronomique (INRA)

## Regenerating argan tree stands in Morocco

Argan (*Argania spinosa*) trees are endemic to Morocco and a source of food for humans and livestock, as well as medicine and cosmetics. In southwestern Morocco, natural argan stands are steadily declining, with little likelihood of their regeneration. CIRAD and its Moroccan partners have developed techniques for vegetative propagation in forests and nurseries with the aim of rejuvenating the aging argan stands. Cuttings, grafting and especially air layering have been used to clone 13 of the 14 trees initially selected for their qualities—some of which were several hundreds of years old. This paves the way for better management of argan genetic diversity and will enable clonal orchards to be planted in the near future. Moreover, improvements in nursery techniques, such as the planting of cuttings in above-



An argan tree at Aoudjoui, Morocco © R. Bellefontaine/CIRAD

ground containers designed with root-guide grooves, has made it possible to produce cuttings that will generate dense adventitious roots and with a faster regrowth rate, thus reducing the length of time that plantations have to be fenced to keep out goat herds. This breakthrough should help to convince rural people to accept the setting-up of future plantations.

**CONTACT** > Ronald Bellefontaine, Montpellier, Genetic Improvement and Adaptation of Mediterranean and Tropical Plants (UMR AGAP)

Bellefontaine R., Ferradous A., Alifriqui M., Monteuis O., 2010. Multiplication végétative de l'arganier (*Argania spinosa*) au Maroc: le projet John Goelet. Bois et forêts des tropiques, 304: 47-59.

**Partners** > University of Marrakech, Centre national de recherche forestière de Rabat, Centre régional de recherche forestière de Marrakech, Direction régionale des eaux et forêts d'Agadir (Morocco)

## *Xanthomonas albilineans*, a small but sturdy genome

The bacterium *Xanthomonas albilineans* causes leaf scald, a serious sugarcane disease that can lead to yield losses in the field and in sugar factories. *X. albilineans* occupies the xylem in sugarcane plants, a special niche that is not a very suitable environment for bacteria due to its morphological partitioning and low nutrient content. CIRAD and partners have just sequenced and annotated the genome of this bacterium. Study findings confirmed that it is unique as compared to that of other *Xanthomonas* species. It is the progeny of the same *Xylella fastidiosa* parent, which also lives only in the xylem. The genome of both of these bacteria has been substantially eroded and they share genes encoding cellulases that are specifically adapted for utilising cell debris found in the sap. The *X. albilineans* genome also contains spe-



Leaf scald on a sugarcane plant © P. Baudin / CIRAD

cific genes that could have an important role in the lifestyle and pathogenicity of the bacterium: genes encoding a type-3 secretion system (SST3), specific to animal pathogens, as well as NRPS genes encoding megaenzymes that catalyse nonribosomal biosynthesis of small molecules.

**CONTACT** > Isabelle Pieretti, Monique Royer, Montpellier, Biology and Genetics of Plant-Pathogen Interactions (UMR BGPI)

**Partners** > Génomscope, French Network on Xanthomonads (FNX)

Pieretti I. et al., 2009. The complete genome sequence of *Xanthomonas albilineans* provides new insights into the reductive genome evolution of the xylem-limited Xanthomonadaceae. BMC Genomics, 10: 616. Doi: 10.1186/1471-2164-10-616.



# Sequencing the genome of two plant trypanosomids

*Two serious palm tree diseases are caused by trypanosomes. Little is known, however, about the diversity of these microorganisms, which have been arbitrarily classified in the *Phytomonas* genus. In 2010, CIRAD launched a programme to sequence their genomes. The initial results revealed that this genus encompasses isolates that differ very substantially.*

**C**oconut hartrot and oil palm marchitez are two diseases caused by trypanosomids transmitted by insect vectors of the *Lincus* genus. In Latin America and the West Indies, these diseases are responsible for significant losses in village plantations. Pesticides are generally used to control these pests in industrial oil palm plantations. Other trypanosomids also attack latex plants, fruits or seeds without causing any wilt. An arbitrary genus name, *Phytomonas*, was given to all of these plant trypanosomids, but it does not at all reflect the extent of their diversity.

CIRAD thus decided to study this diversity within its own plant trypanosome collection. This

unique world collection contains 22 intraphloemic pathogens that were isolated in different countries (Venezuela, Colombia, Ecuador, Grenada, Brazil and French Guiana) and around 40 isolates from latex plants. Molecular marker studies revealed at least eight groups. Characterization of the molecular karyotype of two of them confirmed this diversity: the H group (coconut hartrot) has seven chromosomes that form a 10 Mb genome, while the D group (latex from *Euphorbia* sp.) has 21 for a 25 Mb genome.

Further studies involved sequencing of a hartrot isolate (Hart1, from French Guiana) and a nonpathogenic isolate from *Euphorbia* latex (EM1), as part of a project con-

ducted with Genoscope. Both isolates, which until now have been classified in the same *Phytomonas* genus, only have 75% amino acid sequence homology between them and 40% homology with animal and human trypanosomes, three of which have already been sequenced—*Trypanosoma cruzi*, *T. brucei* and *Leishmania major*. Species annotations revealed very interesting differences in the composition of various Trypanosomatidae enzyme pools. These results have implications in the fields of parasitology, phytopathology and even evolution. ■

CONTACT > Michel Dollet, Montpellier, Plant Resistance to Parasites (UMR RPB)

**Partners >**  
Génoscope, University of Montpellier 1, University of Bordeaux 2, Catholic University of Louvain (Belgium), University of California-Los Angeles (UCLA, USA), University of Georgia (USA), University of Cambridge (UK), University of Edinburgh (UK), University of Glasgow (UK), Bar-Ilan University (Israel), Technion-Israel Institute of Technology (Israel). This research was subsidized under the Agence nationale de la recherche (ANR) SEQTRYPLANT project.



Dollet M. et al., 2010. Current status of the sequencing project on two plant trypanosomatids (*Phytomonas* spp.). In: XIIIth International Congress of Parasitology (ICOPA), 15-20 August 2010, Melbourne, Australia.

Hartrot symptoms on a coconut palm in French Guiana  
© M. Dollet/CIRAD

# Tracking banana weevil movements



A banana weevil fitted with an RFID chip to facilitate monitoring of its movements  
© F. Vinatier/CIRAD

*Black weevils (Cosmopolites sordidus) cause extensive damage to banana plants that they invade. CIRAD launched a study on weevil movements by fitting them with radio-frequency chips with the aim of gaining insight into the dispersal patterns of these pests in the field. A model that simulates plot colonization patterns also demonstrated that the spatial structure of cropping systems had an impact on weevil movements. These results should enhance trapping control operations.*

**I**nfestations of the weevil, which is native to South Asia, now occur in all banana-growing areas, and it is the top-ranking banana pest in many regions, especially in West Africa. The larvae induce damage in banana plants by boring galleries in the bulb, leading to nutrition problems for the plant and sometimes causing it to topple over. But how do weevils move around in heterogenic plantation environments and what criteria do they use to select their habitats? Finally, what plot layout patterns could hamper the colonization of weevil-free banana plantations? A CIRAD team used radiotelemetry and modelling to address these questions.

## Weevils fitted with RFID chips

Adult weevils disperse slowly by walking. Banana plots are colonized from infested adjacent plots or reservoir areas, such as seminatural habitats where wild bananas thrive. The organization of plots in the agricultural landscape thus has a marked impact on weevil movements, as does the layout of different elements within the plots—banana plants, crop residue, cover crops, pheromone traps, etc.

Weevils were thus fitted with radio-frequency chips (RFID) whose emissions were captured by a detector, thus enabling operators to track their movements with 30 cm accuracy. Analysing maps of their pathways highlighted how individuals selected their habitats.

These data were incorporated in the individual-centred model called COSMOS that simulates spatial propagation and attacks of weevils according to different elements of the cropping system. The model was validated by comparing the recorded infestation data with simulated data and then it was used to assess the effects of different spatial arrangements of banana plants on banana weevil behaviour.

## How can a banana plantation be organized to curb pest infestations?

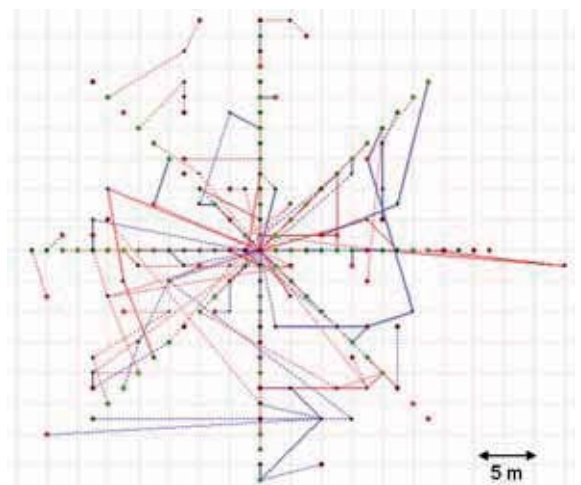
The model revealed that plot colonization was faster when banana plants were sown in a regular pattern rather than in groups. It also revealed that the transition area between the banana plantation and fallows is essential for optimizing trapping operations—a control method used in export banana plantations. These results also enhance

the efficiency in determining where to position intercept traps containing aggregation pheromones. To promote integrated management of banana weevil pests, studies are ongoing on population regulation by natural enemies. ■

CONTACT > Philippe Tixier, Le Lamentin, Banana, Plantain and Pineapple Cropping Systems (UPR)

Partner > Institut national de la recherche agronomique (INRA)

Vinatier F. *et al.*, 2011. Factors and mechanisms explaining spatial heterogeneity: A review of methods for insect populations. *Methods in Ecology and Evolution*, 2: 11-22.



Weevil movements charted by RFID radiotelemetry showing favoured movements of weevils towards a pheromone trap located at the centre of the figure. Male paths are in blue and female paths are in red, while green dots represent sites where the weevils were released  
© F. Vinatier/CIRAD





White grub damage on sugarcane  
© F.R. Goebel/CIRAD

# Tracking greyback cane beetle flights by radiotelemetry

*The miniaturization of radiotelemetry equipment has led to the development of insect tracking methods. In Australia, a CIRAD team tailored this technique for tracking flights of greyback cane beetles in sugarcane fields, where their nymphs cause damage, and in the surrounding vegetation.*

Telemetry techniques have recently been developed for tracking insect movements and collecting information on their dispersal patterns in the landscape. They facilitate pest control when combined with other tools, such as geographic information systems (GIS). CIRAD tailored this technique for monitoring flights of greyback cane beetles (*Dermolepida albohirtum*), which are insect pests of sugarcane crops in Queensland region, Australia.

Beetles were fitted with miniature tags (radiotransmitters) on the tips of their abdomens so as not to hamper flying. They were then released and tracked for 7–10 days via a portable receiver and antenna. Twice daily, a reading was obtained to pinpoint their movements in the natural vegetation and from this vegetation towards sugarcane fields. The flight trajectories were then located on maps via GPS coordinates.

Greyback cane beetles feed and mate on some 20 plant species, especially *Ficus*, *Eucalyptus*, palms, coconut and banana, which sometimes host communities of over 1 000 beetles. They move between these species and sugarcane crops occur via two sequences: at dusk, adults leave the sugarcane fields and aggregate in the surrounding vegetation; at dawn, the females return to the sugarcane fields to lay

their eggs. Helicopter flights to efficiently pinpoint damage areas revealed that 90% of the infested areas were located less than 200 m from adjacent natural vegetation.

Telemetry has already shed substantial light on the bioecology of this insect. Crop field protection could ultimately be optimized. By accurately identifying risk areas, for instance, it would be possible to better target interventions and to reduce field pesticide treatments, which are conducted throughout Queensland. This will be especially

**Partners >**  
BSES Limited (Australia), University of Queensland (Australia), Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia)

important since sugarcane plantations are located close to the Great Barrier Reef whose protection is essential. Applications of this technique for other agrosystem pests are now planned. ■

**CONTACT >** Francois-Régis Goebel, Brisbane, Annual Cropping Systems (UPR)

Goebel F.R. et al., 2010. Quantifying spatial movement of the greyback cane beetle in sugarcane landscape: data available and research needs. Proceedings of the Australian Society of Sugar Cane Technologists, 32: 71-83.



A greyback cane beetle with a tag and antenna fitted on the tip of its abdomen  
© F.R. Goebel/CIRAD

# Early identification of male tilapia

*Tilapia breeding is profitable only if it is solely focused on male populations. Hormonal inversion methods currently used to produce these populations have, however, many drawbacks. CIRAD has been investigating a genetic approach for several years and just discovered a way to precociously select breeders giving all male progeny via a gene present in fry brains.*

Gender control is a major concern for tilapia producers. Males grow faster than females, which lay eggs monthly as of 4 months of age and stop feeding during the mouthbrooding period. The use of male monosex populations enables optimization of tilapia growth in aquaculture, as well as food conversion. However, these populations are mainly produced by hormonal inversion techniques, which raise many contentious issues with respect to the environment and consumers. A CIRAD team has developed an environment-friendly approach based on the masculinizing effect of high temperature, and a genetic approach involving the use of YY male breeders of monosex male progeny.



Male tilapia grow faster than females © J.F. Baroiller/CIRAD

## Producing monosex populations

Indirect approaches such as progeny testing are required to select YY male parents of monosex male progeny since sex chromosomes cannot be distinguished in most fish. Analysis of the sex ratio of offspring can reveal the sexual genotype (XX, XY, YY) of the parents. The only problem is that it is necessary to wait 4–5 months to be able to identify interesting parents by sexing the progeny. All laboratories working on tilapia have thus been analysing the gonads with the aim of finding molecular markers that would enable early, efficient and simple sexing.

## A dimorphic sex-related gene in the brains of fish fry

The CIRAD team decided to study the brains of tilapia fry. This led to the discovery of a gene that was previously considered to be typically present in the gonads of all vertebrates. This gene was found to have major sexually dimorphic expression, occurring much earlier in the central nervous system than in the gonads. Using mixtures of monosex male and monosex female populations, the researchers assembled batches with different known sex ratios (100%, 75%, 50%, 25% and 0% females) and

then conducted blind molecular sexing assays on each batch of 14-day-old fry. The remainder of each batch was preserved and sexed at 4 months using the conventional technique. The sex ratios determined at 14 days corresponded 100% to those determined at 4 months.

This is a further step towards achieving gender control in tilapia using consumer- and environment-friendly approaches. ■

CONTACT > Helena d'Cotta-Carreras, Jean-Francois Baroiller, Montpellier, Integrated and Ecological Intensification for Sustainable Fish Farming (UMR INTREPID)

Poonlaphdecha S. et al., 2011. Elevated *amh* gene expression in brains of male tilapias (*Oreochromis niloticus*) during testis differentiation. Sexual Development, 5: 33–47.





Transporting charcoal in Madagascar  
© P. Montagne/CIRAD

## line 2 \ **biomass energy**

Analysing the conditions  
for the development of  
bioenergies and ensuring  
that they benefit people  
in developing countries



## AGREEMENTS, PARTNERSHIPS

**CIRAD has 13 partnership projects under way** on biomass: analysis of the global potential, timber and fuelwood production (Madagascar, Democratic Republic of the Congo), model development, assessment of the potential of supply chains (jatropha, sorghum, sugarcane, microalgae, etc.), preconditioning of biomass, carbonization, decentralized electricity production (Burkina Faso, Madagascar, etc.).

**In Guadeloupe**, the new European CANN'ELEC project will generate electricity from sugarcane grown in areas that are unsuitable for other crops due to chlordecone pollution.

**French Guiana** has several projects for power generation from biomass within the EDF network. A new power plant was inaugurated at Kourou in 2009.

**In Réunion**, selection of high bagasse-producing sugarcane varieties is under way in collaboration with ADEME, Région Réunion and EDF.

**In Africa**, CIRAD's main partners are the Institut international d'ingénierie de l'eau et de l'environnement, in Burkina Faso, ICRISAT, in Mali, and the Agence de développement de l'électrification, in Madagascar. In Latin America, CIRAD collaborates with EMBRAPA, the University of Paran and CATIE. In Oceania, it works with local authorities on energy independence in the Pacific Islands.



© D. Louppe/CIRAD

## EVENTS, CONFERENCES

**The SWEETFUEL project** was presented in Lyon during the 18th European Biomass Conference and Exhibition and at the AGRO 2010 Symposium organized by ESA in September in Montpellier.

**The second statement adopted by the INRA-CIRAD joint ethical advisory committee for agricultural research** focuses on issues concerning food and nonfood uses of agricultural products, especially with respect to liquid biofuels.

# New strategies for catalytic gasification of biomass

*Gasification is one of the most promising strategies for energy recovery from biomass. It generates a mixture of combustible gases that can be used to produce second-generation synthetic biofuels. However, it has the disadvantage of also generating tars, which reduce the yield and, especially, deactivate catalysts used in the synthesis step. CIRAD and partners in Burkina Faso have managed to reduce this tar production by impregnating metals such as nickel and iron in the biomass at the beginning of the process.*



Bundles  
of eucalyptus logs, Congo  
© D. Louppe/CIRAD



Energy recovery from biomass via thermochemical techniques enables the conversion of any lignocellulosic material directly into useful energy or into solid, liquid or gaseous energy vectors. Biomass gasification can be carried out to generate a mixture of CO- and H<sub>2</sub>-rich combustible gases, called syngas (synthetic gas), which can in turn be used to produce hydrogen or linear synthetic hydrocarbons. This is considered to be one of the most promising processes for synthesizing second-generation biofuels using entire plants. Its development is, however, hampered by the formation of tars derived from the gasification gas, thus lowering yields and, especially, deactivating catalysts used for hydrocarbon or hydrogen synthesis.

## Metal precursors for catalytic cracking of tar

An innovative approach was investigated by the joint CIRAD/2iE biomass-energy and biofuel laboratory set up in Ouagadougou, Burkina Faso. It involves introducing, into biomass, precursors of metals known for their effectiveness for catalytic cracking of tar. In this way, they are able to act as early as the pyrolysis step in the thermochemical conversion process during which primary tars are produced.

Lignocellulosic matrices of beech, eucalyptus and sugarcane bagasse samples were thus impregnated with nickel or iron salts in liquid medium. The active phase of the metals in tar conversion reactions was generated *in situ* as the temperature rose during pyrolysis.

Analysis of the impregnated samples revealed that the insertion of metal cations involved mechanisms of electrostatic adsorption, ion exchange and complexation in hemicellulose, lignin and cellulose microfibrils, which ensure disper-



A joint CIRAD/2iE biomass-energy and biofuel laboratory set up in Ouagadougou, Burkina Faso © J. Blin/CIRAD

sion of the metal in the lignocellulosic matrix. Bagasse was found to absorb the most metals of the three types of biomass studied.

Nickel species evolved during wood pyrolysis to form single crystal nickel nanoparticles (Ni) in the 400–500°C temperature range, with carbon atoms acting as a reducing agent. In the same temperature range, iron species were transformed into amorphous iron oxide nanoparticles (FeO<sub>x</sub>).

## A more effective iron-nickel blend

Both metals are efficient catalysts during pyrolysis, thus reducing the tar content. Pyrolysis tests on the impregnated samples at 700°C revealed that nickel was more efficient in boosting H<sub>2</sub> produc-

tion (over 160%) and in reducing aromatic hydrocarbon production, whereas iron performed best in reducing total tar production (over 70% with bagasse). Impregnation of biomass with an iron-nickel mixture had a complementary and more intense catalytic effect than when a single metal was used.

Catalytic pyrolysis of biomass impregnated with metal salts is a promising technique for reducing tar formation during second generation biofuel production, while also promoting H<sub>2</sub> generation. Further studies are under way to streamline this new catalytic technique, to utilise the impregnated carbon obtained and to recycle the metals. ■

**Partners >**  
Institut des membranes, Institut international d'ingénierie de l'eau et l'environnement (2iE, Burkina Faso)

Richardson Y. *et al.*, 2010.  
*In situ* generation of Ni metal nanoparticles as catalyst for H<sub>2</sub>-rich syngas production from biomass gasification. *Applied Catalysis A-General*, 382: 220-230.

CONTACT > Joël Blin, Ouagadougou, Biomass and Energy (UPR)

# Charcoal in Madagascar: reconciling urban demand and sustainable management



© P. Montagne/CIRAD

*Since 1999, within the framework of sustainable management of forest ecosystems, Madagascar has been implementing a domestic energy policy that should enhance energy supplies—mainly charcoal—for urban communities while organizing supply chains. This policy should ultimately benefit rural households by providing a source of supplementary income through charcoal sales. Based on a case study in the town of Mahajanga, CIRAD and partners prove that sustainable decentralised management of charcoal supplies can be successfully organized for urban centres in Madagascar.*

In Madagascar, charcoal provides nearly 90% of the energy used for cooking in urban households. Energy policies must balance forest ecosystem protection with meeting peoples' daily energy needs. Specifically, this requires sustainable management of forests that are tapped for charcoal production, the organization of supply chains while, indirectly, fighting poverty since the charcoal business provides essential supplementary income for thousands of producers. CIRAD and partners have implemented innovative approaches at all levels of the supply chain, while also setting up a framework for sustainable decentralized management of charcoal supplies in the town of Mahajanga, in western Madagascar.

## Management transfer and training contracts

At the local level, studies were focused on drawing up contracts for the transfer of management from the State to village communities for the sustainable production of charcoal, and on training of stakeholders—charcoal producers,

members of village associations, municipal or State forestry administration representatives. Twenty-two contracts were thus signed and over 400 charcoal producers were trained on improved carbonization techniques. Communal forest control agents were also trained in order to develop a decentralized system of forest control and forest taxation. Regionally, the authorities published a decree that validates the whole system while assigning the forestry administration the task of organizing this supply.

## Charcoal, a staple product

After several consultations with all stakeholders throughout the country, it was possible to propose the State a decree to revise charcoal manufacturing regulations, which updates the legal framework for fuelwood in Madagascar.

**Partners >**  
Centre national de la recherche appliquée au développement rural (FOFIFA, Madagascar), Participation à la gestion de l'environnement (PARTAGE, Madagascar), European Union

Marketing charcoal at Beronono, Madagascar © P. Montagne/CIRAD





## Arina, charcoal in Madagascar

This book reviews studies on charcoal carried out in the vicinity of Boeny, as part of a project on improved carbonization and decentralized forest control (CARAMCODEC, *Arina* in Malagasy). It recommends a pragmatic view and puts forward legal and regulatory proposals for the production of this staple product.



Montagne P. et al., 2010. *Arina, le charbon de bois à Madagascar : entre demande urbaine et gestion durable*. Antananarivo, Cite, 187 p.

Whereas around 80% of the charcoal for the town of Mahajanga is supplied illegally, demand increased from 15 000 to 20 000 t/year between 1999 and 2009, and other sources of energy, especially gas, are beyond the means of urban inhabitants, this pragmatic view outlined in the decree, whereby the resources must be managed to meet urban demand, has been approved by the administration. It thus recognised that charcoal is a staple, like rice and oil, and that its production should be regulated differently from other forest products. ■

CONTACT > Pierre Montagne, Antananarivo, Tropical Forest Goods and Ecosystem Services: Facing Global Change (UPR BSEF)

# Djolibois, a role-playing game for the fuelwood supply chain in Bamako



A role-playing game in progress  
© L. Gazull/CIRAD

*Fuelwood is widely used as a source of energy in Bamako households. This wood comes mainly from natural forest stands growing in the vicinity of the capital. With the aim of coordinating stakeholders in this supply chain and sustainable management of these resources, CIRAD designed a role-playing game to come up with a joint picture of the fuelwood supply system and its potential development patterns.*

Wood fulfils more than 90% of peoples' energy needs in Mali. Around Bamako, fuelwood comes mainly from natural forest stands since plantation areas are too small. Although very little knowledge on the consumption and productivity of woody

vegetation is available, most analysts have concluded that these forest resources are overused.

New forest policies were drawn up as of the mid-1990s to overcome problems concerning the State regulation and also, to some extent, due to the market fail-

CONTACT > Laurent Gazull, Montpellier, Tropical Forest Goods and Ecosystem Services: Facing Global Change (UPR BSEF)

ure following the liberalization of wood prices in 1986. They aimed to decentralize natural resource management through the gradual transfer of management rights to local people. Fifteen years later, these policies have given rise to the outstanding democratization of the entire supply chain in Bamako. One of the current major challenges for the Malian State is to ensure efficient coordination of all stakeholders of the supply chain so as to promote sustainable management of the resources and to certify that this activity enhances economic development.

### A shared view of supply area functioning

In these conditions and in collaboration with the Malian forestry administration, CIRAD began companion research aimed at building a joint picture of the organization of the Bamako supply area in collaboration with all stakeholders of the wood supply chain.

Simulation games have often proved effective as mediation support methods. Aware of the fact that stakeholders' choices often depend on the location of the resources with respect to Bamako, the researchers wanted to put the players in situations where difficulties associated with space—movements, spatial partitioning of information, isolation of harvesting areas—are key factors of the game. They thus created a 'field' game called Djolibois in which players must move around physically in an area whose organization includes the major constituents of the Bamako supply area. The game takes place in a large room or outside. It has been played four times in Mali with different players.

### Information, a key feature

Djolibois boosts the awareness of players on the importance of information in their activities—lacks, needs and sharing. For anyone outside of the supply chain and for fuelwood professionals, it is an occasion to gain insight into the overall functioning and regulation mechanisms of the supply chain. It also offers certain professionals the opportunity to test strategies associated with their professional activities through a game.

Djolibois has proved to be a powerful and widely accessible tool to come up with a joint picture of the supply system and possible changes. It is a starting point for building an organized and regulated sustainable supply chain for Bamako. ■

Gazull L., Gautier D., Becu N., 2010. Usage d'un jeu de rôles pour l'analyse préalable d'un SIG : Djolibois, un jeu spatialisé pour l'approvisionnement en bois-énergie de la ville de Bamako (Mali). *Revue internationale de géomatique*, 20: 7-36. Doi : 10.3166/riig.20.7-36







A catering establishment in Hanoi,  
Vietnam © P. Doucet/CIRAD

## line 3 \ food

Innovating  
to make food  
accessible,  
varied and safe

## AGREEMENTS, PARTNERSHIPS

The **World Bank** aims to recognize CIRAD as an expert in strategic policy direction and advice on questions of food security and of agricultural and rural development. This co-operation was discussed during a seminar on the strategic convergences of institutions in September in Washington.

CIRAD and **VAAS, Vietnam Academy of Agricultural Sciences**, renewed their collaboration through an agreement within the framework of the MALICA, Markets and Agricultural Linkages for Cities in Asia, research consortium, whose objective is to contribute to food security and safety in Vietnam and neighbouring countries.

The **European AFTER, African Food Tradition Revisited by Research, project** is seeking to improve traditional African products and the associated know-how for the benefit of consumers and producers in Africa and Europe.

**Health foods:** CIRAD and the Agro-Novae company have launched a programme, CARHES (CARotenoids-HESperidin), to study the influence of the geographic origin of citrus fruits on their nutritional microconstituents and to produce extracts enriched with these compounds. This programme is subsidised by OSEO, a public enterprise for supporting innovation. With the Dialpha company, a specialist in health ingredients which develops compounds with strong added value based on natural plant extracts, the Qualisud research unit will study several agricultural co-products or by-products particularly rich in phenolic compounds, and these will be tested for their biological efficacy on pre-diabetes.

## CONFERENCES, PUBLICATIONS, COMMUNICATION

The review **Fruitrop**, edited by the CIRAD Market News Service, regularly publishes economic information: summer citrus fruits, pineapple, avocado, banana, mango, apple and pear, roots and tubers and sea freight etc. have been the subject of special reports in 2010.

**Les aliments à visée santé** (a focus on the topic of healthy diets) was the subject of a conference organized by the Centre du droit à la consommation, CIRAD and Montpellier 2 University. A healthy diet is not just a matter for consumers and health authorities, but is also a major economic issue for the agrifood industry.

A **prize from the Vietnam Academy of Agricultural Sciences** was awarded to Paule Moustier, an economist at CIRAD, for her work coordinating the MALICA project for more than five years.

The **International Cocoa Awards (ICOA)** are an initiative of three organizations (CIRAD, Bioversity International and Event International), supported by the cocoa industry. The prizes were awarded during October's Salon du chocolat in Paris.

The first statement adopted by the **INRA-CIRAD joint ethical advisory committee for agricultural research** focuses on food security and models of food consumption.

# The imperfect transmission of world prices to domestic agricultural markets in sub-Saharan Africa

*How do international agricultural commodity prices influence prices on domestic markets? A study conducted by CIRAD on the transmission of the surging international price of rice in 2008 on the prices of food in five sub-Saharan African countries shows that this influence varies according to the market share of imported products in the diet of the population and the degree of substitution between imported food and food produced locally. The results prove that, above all, the prices of food products are determined by domestic markets.*



J. Weij/CIRAD





In Mali, rice prices are primarily determined by local rice supply  
© E. Daou/CIRAD

**I**n order to inform the debate on the impact of the surge in international prices experienced in 2007-2008 on the food systems in sub-Saharan Africa, the Foundation for World Agriculture and Rurality (FARM) asked CIRAD to measure the transmission of prices between international markets and domestic markets. The objective was to evaluate the extent to which rises in international prices were reflected in the prices of food products grown locally and could therefore encourage small producers to increase their production to reduce their country's reliance on imported food. This project was carried out by a team of economists from CIRAD and its partners in developing countries specialized in the econometric analysis of time series data and in the study of international agricultural markets.

## Rice, emblematic of soaring prices

The study was conducted on rice. This is, in fact, a product that is emblematic of soaring prices on international grain markets and one of the major African food imports. The permanent or temporary inten-

sity of the transmission was measured on the basis of trends in rice prices on the international market, imported rice on domestic markets, rice produced locally and other local staple food products, such as millet, plantain and cassava. Price trends for imported rice, local rice and other food products were analysed in five countries: Senegal, Mali, Niger, Cameroon and Madagascar.

## An unequal transmission of international prices

In the case of Senegal, where imported rice is a staple food, there is a co-integration in the relationship between the international price of rice, the domestic price of imported rice and the price of local rice; the international price therefore always determines domestic rice prices. However, in the case of Mali and Madagascar, where imported rice only tops up the domestic rice supply, the price of rice is primarily determined by the local supply. Concerning the diffusion of the rice price hike on the international market to prices of other food products, the relation-

ships tested do not show any permanent transmission, although in the short term price rises at the global level disturbed temporarily price trends on the food markets, these shocks were absorbed in a few months.

These results underline the complexity in the setting of food prices in African countries, even in food shortage situations. The imperfect transmission of international prices to local food products confirms the strong segmentation between imported and local food supply chains. These segmentations are a result of geographical (landlocked, coastal zone), social (income levels) and cultural (food practices) specializations, but also of trade policies (tariffs). Therefore strategies for food security cannot rely only on the regulation of imported food products, as the price levels of the latter do not necessarily have a structural impact on domestic markets. A price-based incentive policy can only have a long term positive impact on local production if it is embedded in a strategy that promotes a higher substitutability of local staple foods for imported food products. ■

**CONTACT >**  
Frédéric Lançon,  
Montpellier,  
Actors, Resources  
and Territories  
in Development  
(UMR ART-Dev)

**Partner >**  
Foundation  
for World  
Agriculture and  
Rurality (FARM)

David-Benz H.  
et al., 2010.  
*L'imparfaite  
transmission des  
prix mondiaux  
aux marchés  
agricoles  
d'Afrique  
subsaharienne.*  
FARM, CIRAD.

# Developing markets through innovation: cowpeas in Burkina Faso

*In West Africa there are a multitude of development projects leading to technical innovations. But what are their real impacts on the markets? And how can they make it possible to balance supply and demand? An analysis conducted by CIRAD on new packaging for cowpeas developed in Burkina Faso proves that innovation can play a leading role in the market integration of family farming.*

CIRAD provides methodological expertise for the agricultural development programme in Burkina Faso, which began in 2006. It therefore participated in identifying and selecting those initiatives which would improve the market integration of rural producers while strengthening their performance. Several of these initiatives aim to better develop local production, enlarging or creating new markets, reducing market monopoly situations or improving the total supply.

For the cowpea supply chain, progress is important in terms of developing local production. Markets are rapidly developing in the country's large towns and across the West Africa region. However, this expansion is slowed by problems in preserving cowpeas. To reduce losses caused by weevil infestations and to standardize cowpea packaging, a new pack has just been developed: triple bagging.

Studies conducted by CIRAD have confirmed the advantages of this innovation: it makes it easier to adjust supply and demand for markets which are currently volatile and can therefore play a leading role in the market integration of family farming.

Building on this experience, CIRAD currently provides support to public organizations and private companies in order to capitalize on the results achieved in other supply chains in recent years. This position enables CIRAD to lead reflection on reconfiguration processes for income-generating supply chains

in a context where there is both a decentralization of state power and the opening up of markets. Supply chain analysis is being used as a decision support tool for the sustainable development of rural and urban areas. ■

CONTACT > Marie-Hélène Dabat, Ouagadougou, Actors, Resources and Territories in Development [UMR ART-Dev]

Dabat M.H. et al., 2010. Caractérisation des filières au Burkina Faso et insertion de l'agriculture aux marchés. In: Colloque international : Quelle agriculture pour un développement durable de l'Afrique? CEDRES, 6-8 December 2010, Ouagadougou, Burkina Faso.

**Partners >**  
Programme d'appui au développement de l'agriculture du Burkina Faso (PADAB II), Danish Agency for International Development (DANIDA), Secrétariat permanent de la coordination des politiques sectorielles agricoles (SP-CPSA), Ministère de l'Agriculture, de l'Hydraulique et des Ressources halieutiques (Burkina Faso), Institut de l'environnement et de recherches agricoles (INERA, Burkina Faso)



Cowpeas infested with weevils (left) and cowpeas stored in a triple bag (right)  
© A. Sanon/University of Ouagadougou

## Evaluating the impact of processing on the nutritional value of foods

The processing of food products has a considerable impact on the final nutritional quality of the food in question. A CIRAD team has therefore evaluated different preservation processes using two nutritional indicators, SAIN and LIM, developed in 2008 in response to European regulation seeking to improve information on processed foods. The study followed the nutritional

scores of two products, apple and pork, during their processing using a traditional drying process and through a new process, osmotic dehydration. The nutritional scores varied as a function of the transfer of mass during processing, with critical points at certain stages of the technical processes. The final nutritional quality of the products was not the same for the two proce-

esses. A choice of technical procedure can therefore change the nutritional quality of a food and can maybe influence food labelling. This work also shows the limits of using global nutritional scores to evaluate a process.

CONTACT > Nawel Achir, Montpellier, Integrated Food Quality System [UMR Qualisud]

**Partner >**  
AgroParisTech

Achir N. et al., 2010. Ability of some food preservation processes to modify the overall nutritional value of food. Journal of Food Engineering, 100: 613-621. Doi: 10.1016/j.jfoodeng.2010.05.009

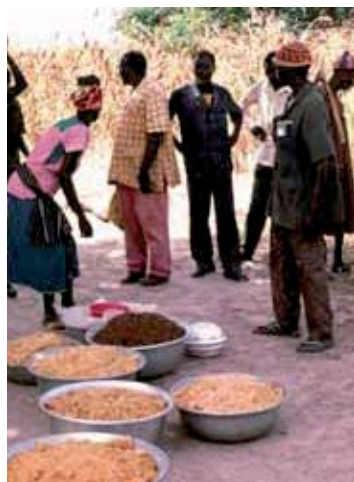


# Supporting the development of food supply chains in West Africa

*As part of the discussions launched by AFD and IFAD on their strategy to support for food supply chains in West Africa, CIRAD, in association with WECARD and CILSS, was asked to conduct a study on production areas and consumption in the region. The results call into question the image of a West Africa which is unable to feed itself. This is a false image, but is still largely widespread around the globe.*

**A**FD and IFAD undertook a joint reflection on their strategy of intervention to support the development of food supply chains in West Africa. These two institutions entrusted to CIRAD, in association with WECARD and CILSS, a study designed to map production areas and consumption in the region. This study was based on mapping changes in growing areas, yields and production at the sub-national scale. It highlighted the strong growth in food production that West Africa has experienced since the 1980s. This growth does not result solely from an extension in the land devoted to food production, but also, in some areas, to an intensification in crop production. As for changes in rural and urban demand, an initial analysis shows that, in economic terms, the West African food market is largely supplied by local and regional production; imports are a feature of only cities in certain countries. This observation puts into perspective the image of a West Africa unable to feed itself.

CIRAD and its partners also organised a collective expertise workshop in order to identify the constraints and possible levers for the food supply chains identified as priorities by the Economic Community Of West African States



West African food markets are largely supplied by local production chains  
© J. Chantereau/CIRAD

(ECOWAS) and the West African Economic and Monetary Union (WAMU). This workshop, which was held in Ouagadougou, made it possible to develop courses of action to accompany the development of these supply chains, in particular improving market access for producers. The extension of transport and communication infrastructures and, especially, the development of processing and marketing activities, appear to be key factors for ensuring growth in agricultural production, even though certain agronomic constraints were also identified. ■

**CONTACT >**  
Marcel de Raissac,  
Montpellier,  
Office of the  
Director General  
in charge of  
Research and  
Strategy

**Partners >**  
Agence française  
de développement  
(AFD), International  
Fund for Agricultural  
Development (IFAD),  
West and Central  
African Council  
for Agricultural  
Research and  
Development  
(WECARD),  
Comité permanent  
inter-Etats de lutte  
contre la sécheresse  
dans le Sahel (CILSS)

## Near-infrared spectroscopy for analysing shea butter

Butter extracted from nuts of the shea tree (*Vitellaria paradoxa*) has a strong potential in the food and cosmetic industries. To precisely evaluate this potential, it is essential to better understand the diversity of the chemical composition of nuts and therefore to develop a fast, non-destructive and precise method for characterizing them. Near-infrared spectroscopy (NIRS) offers advantages in this area, but requires reliable calibration. NIRS has been used to analyse a wide sample of nuts (nuts from 624 trees were harvested) from trees in different countries (Senegal, Mali, Burkina Faso, Ghana and Uganda). These analyses, which concerned moisture and fat content and fatty acid profiles, confirm the differences between trees from the West and the East of the African continent; the latter have higher levels of fat and oleic acid. The calibration equations developed for each constituent were revealed to be effective: the calibrations for moisture and fat help to give a precise determination of these characteristics, and indeed for stearic and oleic acids. This study, funded by Innovkar, opens the way to high-throughput phenotyping of shea nuts and the development of breeding of this major species in African agroforestry systems.

**CONTACT >** Fabrice Davrieux,  
Montpellier, Integrated Food Quality  
System (UMR Qualisud)

**Partners >** Institut d'économie rurale  
(IER, Mali), Makerere University (Uganda),  
Institut sénégalais de recherches agricoles  
(ISRA, Senegal), Centre national de la  
recherche scientifique et technologique  
(CNRST, Burkina Faso)

Davrieux F. et al., 2010. Near infrared spectroscopy for high-throughput characterization of shea tree (*Vitellaria paradoxa*) nut fat profiles. Journal of Agricultural and Food Chemistry, 58: 7811-7819. Doi: 10.1021/jf100409v

# A biological barcode for food products

*It is often impossible to retrace with certainty the origins of food products coming from developing countries when they arrive on European markets. While the documentation system based on barcodes works well in Europe, it is difficult to implement in developing countries. From this emerged the idea of identifying the precise origin of foods by analysing their production environment thanks to the micro-organisms present on their surface. CIRAD has recently developed an effective and particularly promising molecular method.*

The traceability of food products is currently a regulatory concern in terms of both detecting fraudulent labelling and protecting those products which benefit from a certificate of origin. But the documentary systems used in this area are difficult to implement in developing countries, as is the monitoring of products during processing. From this comes the idea of using biological analysis of the commensal flora of food products to determine their origins.

## A fast and reliable technique

In this domain, the skin of foods can prove particularly informative: the skin hosts a community of micro-organisms specific to the biological and human environment in which it has been produced. By analysing fragments of the DNA of these micro-organisms, it is possible to construct a 'biological barcode' which is specific to each geographical origin. A new global molecular method, capable of analysing at the same time the bacteria, yeasts or fungi present on food products, has recently been finalised by a CIRAD team. It is called PCR-DGGE, polymerase chain reaction (PCR) combined with denaturing gradient gel electrophoresis (DGGE).

This method makes it possible to establish, in less than 24 hours, the bacterial, yeast or fungal profile of some thirty food samples. More rapid than other microbial tech-

niques, it avoids the precise analysis of micro-organisms while making it possible, thanks to the sequencing of the band contents, to determine the microbial species.

## First trials on fish and fruit

The discriminative power of this technique has been proved in three situations. The first concerns fish of the species *Pangasius hypophthalmus*, raised in the waters of the Mekong River in Vietnam. The bacterial profile is absolutely identical for fish originating from the same fish farm, but differs between the five farms which were studied, despite the fact the farms are located in the same branch of the Mekong River. Variations in water and environmental quality are therefore sufficient to lead to a notable effect on bacterial ecology.

The same result was obtained when analysing mandarins from Morocco and Spain. Their bacterial profiles vary according to their origin, and these differences are linked to the environment and also to the crop protection programme applied.

Finally, in the third case, the study concerned yeasts and fungi on physalis, a small exotic fruit from Egypt which is becoming increasingly popular in Europe. Here, once again, significant differences were recorded in migration profiles between different production regions.



*Pangasius hypophthalmus* in Vietnam © J. Lazard/CIRAD

These initial trials prove that the microbial communities present on foods are strongly linked to their environment and constitute specific biological markers of their production areas. In the future the PCR-DGGE technique will offer a powerful tool for identifying these markers. ■

CONTACT > Didier Montet, Montpellier, Integrated Food Quality System [UMR Qualisud]

El Sheikh A., 2010. Determination of the geographical origin of fruits by using 26S rDNA fingerprinting of yeast communities by PCR-DGGE: An application to shea tree fruits. *Journal of Life Sciences*, 4: 9-15.

**Partners >**  
Phylogene-Nîmes,  
Pôle de transfert  
agroalimentaire  
régional  
Languedoc-  
Roussillon,  
Innovkar European  
project

The method consists in extracting all the micro-organisms present on the food in one operation, followed by the extraction of DNA of each microbial family, also in one operation. A single PCR amplification is then conducted for each microbial family. The amplified fragment measures between 236 and 260 base pairs (BP) according to the family. The PCR products are then separated by DGGE and the gels stained and photographed. The images obtained are analysed statistically after the alignment of spots using an image analysis program. The profile thus created is considered as an image of all the principal micro-organisms present in the samples, a band corresponding to a unique sequence type, or phylotype, in other words, and in the majority of cases, a species of micro-organism.



# First natural waxy cassava starch

*The industrial starch market is undergoing major expansion, but certain specific industrial uses cannot be satisfied by native starches and chemical or physical modification is necessary.*

*These modifications are often harmful to the environment and generate additional costs.*

*Natural mutations in the cassava biosynthesis pathways were recently discovered at CIAT (International Center for Tropical Agriculture, Colombia). CIRAD, in partnership with CIAT, carried out a study on the physicochemical and functional properties of one of these starches, which could find interesting industrial applications and create new opportunities for cassava starch produced in tropical areas.*

**F**ive crops currently fulfil the demand for industrial starch: maize, wheat, potato, rice and cassava. Cassava starch is particularly important for its specific functional properties and it constitutes the largest source of starch in tropical regions. An amylose-free spontaneous mutant also known as waxy starch genotype was among the mutations recently discovered.

In order to evaluate the industrial potential of this waxy starch compared with other starches available on the international market, CIRAD and its Colombian partners have compared its physicochemical and functional properties to those of native starches, waxy or normal, of maize, rice, potato and cassava, and COLFLO® 67 modified waxy maize, and the aptitude of its gels to resist the technical stresses generated by manufacturing or conservation processes. One of the findings was that waxy

cassava starch gels were very clear and developed a considerably shorter maximum absorption wavelength in the presence of iodine when compared with normal cassava starch. They also had a superior viscosity to normal cassava starch, and intermediate between waxy starches from potato and maize. None of the waxy starches studied showed separation (syneresis) when their gels were stored at 4°C. However, waxy cassava starch was the only one not showing any syneresis after 5 weeks of storage at -20°C.

Its unique functional properties and a production cost lower than that of its competitors on the market, such as potato and cereals, make waxy cassava starch a very promising industrial ingredient. Applications will certainly be found for

this novel starch in the natural starch sector (non-GMO and non-chemically modified starches), mainly for those products requiring gels with higher viscosity and clarity and for frozen or refrigerated food products. ■

CONTACT > Dominique Dufour, Cali, Integrated Food Quality System (UMR Qualisud)



Iodine staining of a normal root (blue) and in a waxy cassava root (light brown)  
© T. Sánchez/CIAT

**Partners >** Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture, CIAT, Colombia), Universidad Nacional de Colombia

Sánchez T., Dufour D., Moreno I.X., Ceballos H., 2010. Comparison of pasting and gel stabilities of waxy and normal starches from potato, maize, and rice with those of a novel waxy cassava starch under thermal, chemical, and mechanical stress. *Journal of Agricultural and Food Chemistry*, 58: 5093-5099. Doi: 10.1021/jf10016066

## A reference book on vanilla

This reference book on vanilla provides a comprehensive overview of current knowledge in the fields of diversity and genetic resources, growing practices and pest and disease control. It also addresses the biosynthesis processes, the precursors of aromas during the

development of pods, the impact of traditional processing for releasing these aromas, the microbiological quality of vanilla and authentication of the finished product. Finally, it examines the production supply chains, notably in emerging countries such as

China, India and the countries of East Africa. Specific chapters are devoted to production in French Polynesia and Réunion. Written by some 50 specialists, this reference book fills a large gap: the last review of such scope on this aromatic orchid dates back to 1954.

Odoux E., Grisoni M., 2010. *Vanilla*. Boca Raton: CRC Press, 387 p.



Brazil nut: husk, shell and kernel  
© C. Brabet/CIRAD

# Preventing and reducing mycotoxin contamination

*Mycotoxins, which are produced by certain fungi in or on foods, contaminate close to 25% of the world's crops. They can cause serious intoxication in both humans and animals. For more than 10 years, CIRAD, in collaboration with its Southern partners, has been conducting research to prevent and reduce mycotoxin contamination in agri-food supply chains, and in particular in coffee and Brazil nuts.*

**M**ycotoxins are toxic secondary metabolites produced by fungi both in the field and after harvest on a wide range of foods [cereals, peanut, nuts, coffee, cocoa, grapes, spices etc]. They can cause acute or chronic intoxications in both humans and animals which are sometimes fatal. Numerous countries, particularly in Europe, have set maximum acceptable levels for mycotoxins in order to protect the health of consumers. In Europe, for direct human consumption, the maximum level for ochratoxin A in roasted coffee is fixed at 5 micrograms per kilo, and the level of total aflatoxins in Brazil nuts must not exceed 10 micrograms per kilo, with a limit of 5 micrograms for aflatoxin B1. CIRAD and its partners are conducting research to control ochratoxin A in coffee and aflatoxins in Brazil nuts.

## Ochratoxin A contamination in coffee

The work has examined the impact of coffee bean damage and roasting on ochratoxin A contamination. The results revealed that beans with agronomic defects are much more contaminated than healthy beans. Beans damaged by insects [coffee berry borers, antestia bugs or fruit flies] or by other fungal

attacks, such as anthracnose, play a role in the contamination of coffee. Removing these damaged beans greatly reduces ochratoxin A contamination.

The roasting process is a heat treatment which provides coffee with its aroma, colour and body. It also has an impact on ochratoxin A content. Two roasting techniques, which employ different temperatures, have been studied to gauge their effect on the contamination level of green coffee beans. Roasting in drums, with indirect and intermittent heating, reduces the ochratoxin A content by 90%, while using the fluidized bed technique, with direct and continuous heating in a current of hot air, the reduction is 63%. This study thereby provides us with information on the thermal stability of ochratoxin A.

## Controlling aflatoxins in Brazil nuts

Brazil nuts are one of the major non-timber forest products of extractive exploration in the Amazon region. Strengthening of the European regulation on the maximum level of aflatoxins and the systematic inspection of batches of unshelled nuts imported from Brazil produced a reduction in exports to Europe of almost 90% between 2000 and 2004.

CIRAD, along with its Brazilian and Swedish partners, has shown that the presence of aflatoxins arises from insufficient drying of the nuts [either in the sun or through the circulation of natural air] and from storage over several months in producer communities in the forest before onward transport to industrial sites. The batches delivered are therefore already highly contaminated and the sorting methods used in the industry are not effective in reducing contamination of unshelled nuts. Statistical models were developed in order to predict the production of aflatoxins in nuts according to environmental and ecological factors. On the basis of these results, the Codex Committee on Contaminants in Food [CCCCF] proposed to revise the guide for Good Extractivistic Practices [GEP] for Brazil Nuts of the Codex Alimentarius.

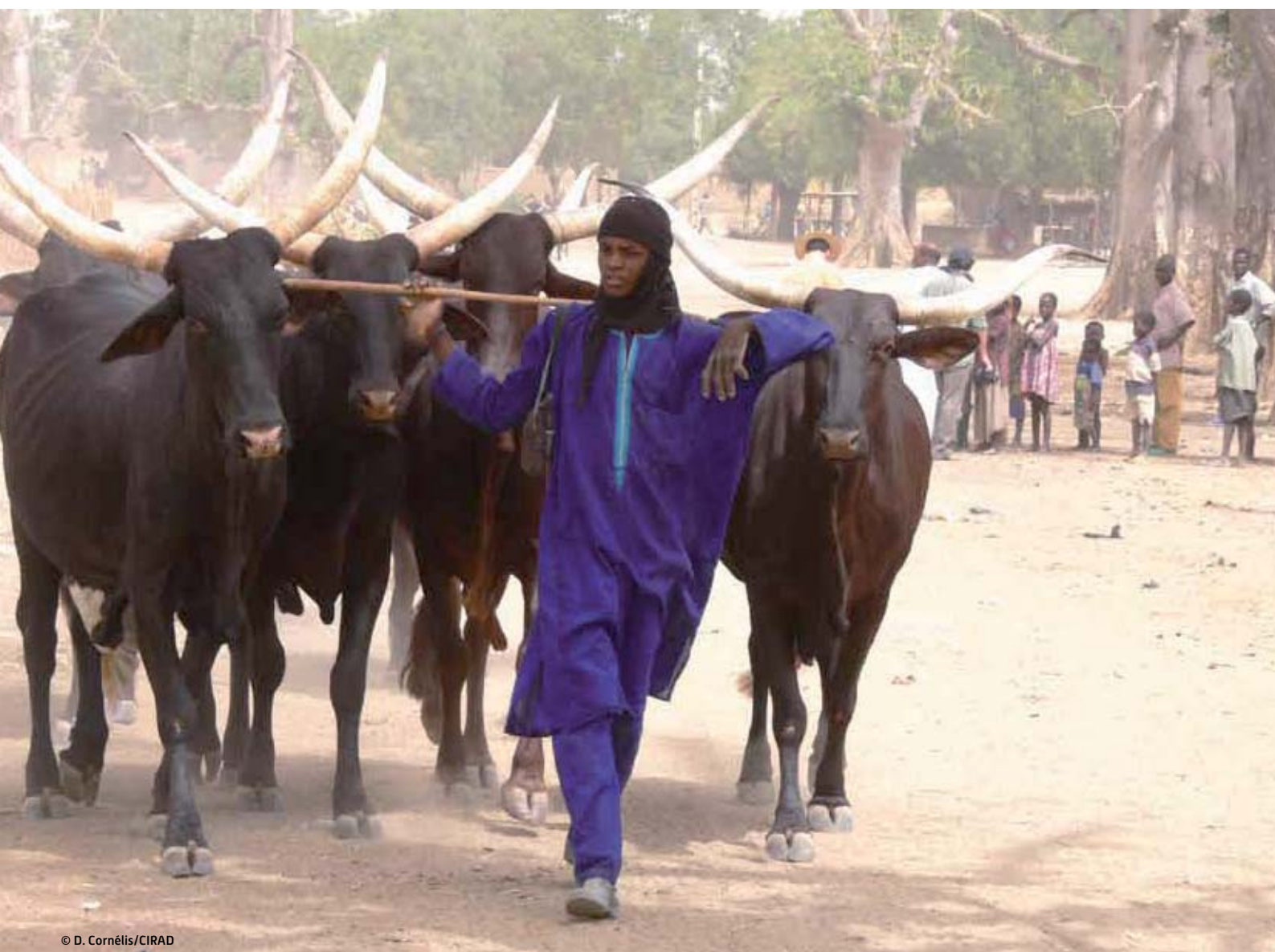
Today, research is directed towards the characterization of microbial ecosystems, in relation to toxigenic fungi, and the development of pre and post-harvest bio-control measures, such as elicitation, competition, degradation and adsorption. ■

**Partners >**  
World Trade Organization (WTO), Standards and Trade Development Facility (STDF), Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA, Brazil), Ministério da Agricultura, Pecuária e Abastecimento (Brazil), National Food Administration (NFA, Sweden), Instituto tecnológico de Vera Cruz (ITV, Mexico), Universidad Central de Venezuela, Universidad Ezequiel Zamora (Venezuela), Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF, Dominican Republic), the private sector

Duris D. et al., 2010. Ochratoxin A contamination of coffee batches from Kenya in relation to cultivation methods and post-harvest processing treatments. Food Additives and Contaminants, 27: 836-841.

CONTACT > Catherine Brabet, Noël Durand, Montpellier, Integrated Food Quality System (UMR Qualisud)





© D. Cornélis/CIRAD

## line 4 \ **animal health and emerging diseases**

Foreseeing and  
managing infectious  
disease risks linked  
to wildlife and  
domesticated animals

## AGREEMENTS, PARTNERSHIPS

The **PARSEL project** monitors the movements of livestock and wild hoofed animals on the border of a national park in Zimbabwe in order to understand and limit the spread of certain diseases. The results obtained since 2008 are encouraging and the protocol has recently been extended to South Africa and Mozambique.

Several agreements have been signed with the FAO to contribute to the **Field Epidemiology Training Programme (FETP)** in China, to provide expertise on **avian influenza** in Egypt and to study the eco-epidemiology of **Rift Valley fever** in Botswana. The FAO has financed the **Chobe and Ngamiland Interface Disease Investigation (CNIDI)** project with the aim of establishing preliminary data on the circulation of zoonotic diseases at the interface between fauna and livestock in the Chobe national park and the Okavango delta in northern Botswana. This project, coordinated by CIRAD from South Africa, has made it possible to screen a thousand head of livestock and 170 wild buffalo both inside and on the periphery of these two protected areas.

## CONFERENCES, PUBLICATIONS, COMMUNICATION

A workshop on parasitic, bacterial, genetic and viral diseases of medical and veterinary interest in Africa was held from 22 to 26 November 2010 in Bobo-Dioulasso, Burkina Faso. CIRAD, with its partners from the University of Pretoria, presented the main results of a project for the development of an epidemiological network for **monitoring foot and mouth disease in the cross-border Great Limpopo Transfrontier Conservation Area (GLTFCA)**, coordinated from South Africa for the past four years. These results are now helping to define a more ambitious project for managing this disease.

The **EDEN project** (Emerging Diseases in a changing European Environment) has produced numerous results, which were presented to the scientific community and the media at its final conference in Montpellier in May. One of the results of the conference was a report in six languages on the Euronews channel concerning the role of woodland rodents in tick-borne disease transmission in Central Europe.

**Emerging infectious animal diseases in the Mediterranean:** a seminar on research into emerging infectious animal diseases and animal health in the Mediterranean was organized by INRA and CIRAD in Montpellier in October.

Methods for evaluating surveillance networks were the topic of an international seminar held in Bangkok in December within the framework of the **REVASIA project**. This seminar brought together French and Asian project partners (Cambodia, Thailand and Vietnam) and overseas observers (Australia, United Kingdom, United States, OIE and FAO).

The analysis of data from different **GRIPAVI project** sites (in Africa and Asia) was the focus of training sessions at the University of Pretoria and the University of Zimbabwe in the fields of biostatistics and the analysis and modelling of social networks.

The **GREASE network**, the regional network for the management of emerging epidemiological risks in South-East Asia, was extended to China.

The annual meeting of the **CERoPath project** was held in Vientiane, Laos, in November 2010 to draw up an initial assessment on emerging rodent diseases in South-East Asia.

# Liposomes: an innovative system for vaccination

*While the effectiveness of a vaccine relies on the choice of antigens that it contains, it depends equally on the delivery system: it should target the key cells for immune response and take into account the routes of infection.*

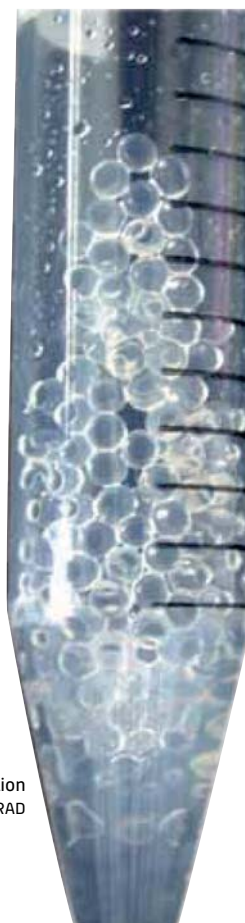
*Due to their modular structure and ease in preparation, liposomes can easily serve for this purpose. Researchers at CIRAD have recently taken advantage of the physicochemical properties of these particles to design vaccines for veterinary use.*

The effectiveness of a vaccine relies on identifying the components of the pathogenic agent capable of inducing a protective immune response, but also on the delivery system in the host. The route of immunisation is equally important. In the case of a respiratory or digestive disease, it is essential to induce immunity at the point of entry of the micro-organism.

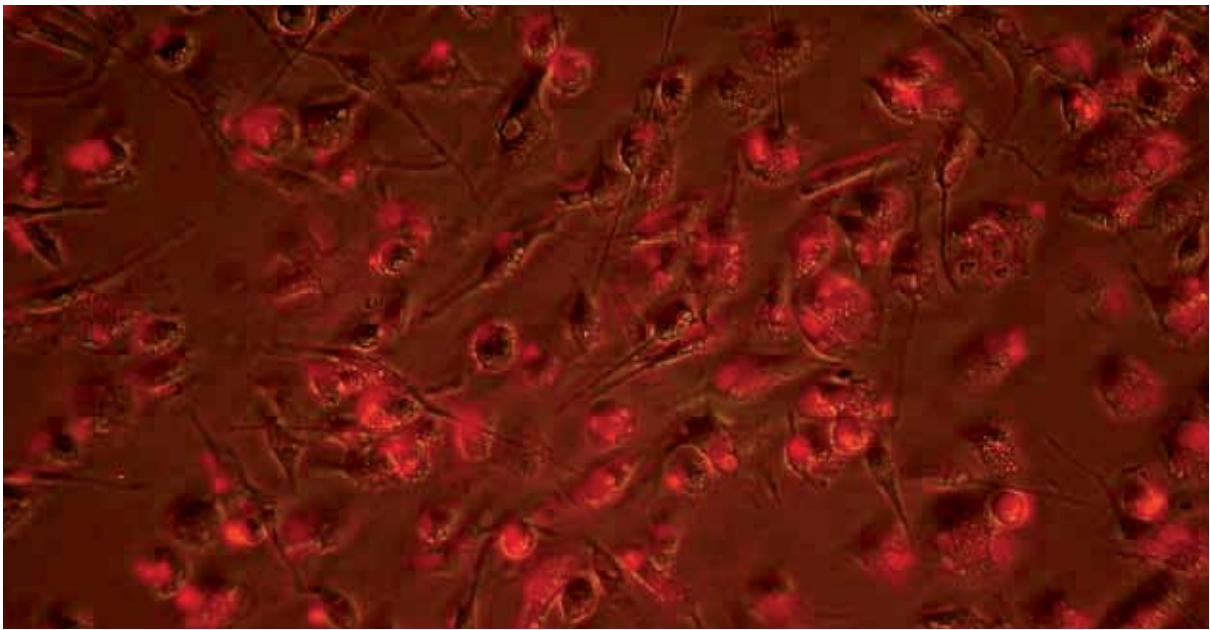
## Liposomes: a simple and cost-effective technique

Liposomes are artificial lipid vesicles capable of encapsulating and protecting proteins or genetic material. Their structure and composition are flexible, and

Formulation of liposomes for oral vaccination of trout © M. Mockey/CIRAD







Transfection of bovine cells by liposomes loaded with phycoerythrin  
© M. Mockey/CIRAD

they can contain large quantities of compounds. They are particularly recommended for delivering vaccines and medicines systemically or through the mucosal route. Their use has been developed in human medicine over the past few years, but their use remains little explored within veterinary medicine. Liposomes present, however, undeniable advantages in this domain because they are simple to implement and production costs are low. CIRAD is therefore interested in liposomes for vaccination against animal diseases, and is conscious of the fact that this technology could be easily transferable to developing countries.

### Oral vaccination of cattle

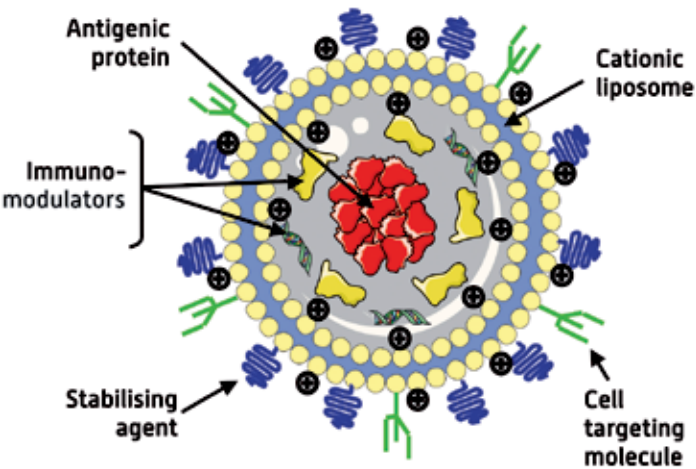
The first study was conducted on a vaccine against bovine tuberculosis which, if it could be administered orally, would reduce the cost of vaccination campaigns. To develop this vaccine, several formulations of liposomes - neutral, cationic and anionic - were tested *in vitro* to evaluate their capacity to transfect bovine immune cells. Cationic liposomes have proved the most effective, with more than 80% of cells transfected and a protein encapsulation rate of more than 90%.

Liposomes of this type containing two vaccine antigens against tuberculosis were tested on mice and the immune response induced was higher than that achieved with a simple injection of antigens. Evaluations on bovines are now envisaged.

### Oral vaccination of farmed trout

The second experience was focused on genetic (DNA) vaccination of farmed trout against viral haemorrhagic septicaemia (VHS) through the oral route. This vaccination

method could be of considerable interest in aquaculture where, until now, vaccination has been by injection, a technique which is expensive and stressful for the fish. An innovative vaccine formulation has been developed: it is based on liposomes containing the gene of VHS's G protein. After being delivered orally, the G gene has been detected in the digestive tract of the fish and a humoral and cellular immune response specific to the virus was obtained. The protective efficacy is now being assessed, but the results are already encouraging and a patent has been filed. ■



Cationic liposomes offer advantages for veterinary vaccinology

CONTACT > Laurence Dedieu, Emerging and Exotic Animal Disease Control (UMR CMAEE)

Dedieu L. et al., 2010. Nouveaux liposomes de vaccination génique. Patent.

Heegaard P. et al., 2011. Adjuvants and delivery systems in veterinary vaccinology: current state and future developments. Archives in Virology, 156: 183-202. Doi: 10.1007/s00705-010-0863-1

Partners > Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA, Spain), European Union

# Optimizing tsetse fly eradication campaigns in West Africa

*In Burkina Faso, Guinea and Senegal, three ambitious eradication projects against tsetse flies have recently been launched. They are based on the results obtained by CIRAD and its partners on the ecology of fly populations and their location. The knowledge and methods will be used to optimize, in each situation, the battle against African trypanosomoses.*

In West Africa, animal trypanosomoses transmitted by tsetse flies have a considerable economic impact on livestock production. A huge pan-African eradication campaign (PATTEC) was launched in 2001 at the continental level. National programmes have recently started in Burkina Faso, Guinea and Senegal. Research plays a determining role in this by studying target populations and in developing methods to locate their habitat.

## In Senegal, an isolated tsetse population

In Senegal, one of the main objectives was to accurately define the infested area. By combining data from botanical surveys on the ground, remote sensing, geographical information systems (GIS) and GPS, researchers were able to reduce the area for sampling by 96%. Then, thanks to the mapping of favourable habitats using remote sensing, veterinary service personnel, guided by GPS, were able to define the area infested by tsetse flies (*Glossina palpalis gambiensis*), an area of about 525 square kilometres, as they tracked the insects to the very edge of the Niayes region.

Genetic analyses have also been carried out with the help of micro-satellite and mitochondrial markers, coupled with morphometric analysis. They have shown that the tsetse population was completely isolated from the tsetse belt situa-



*Glossina palpalis gambiensis* in its natural resting place © O. Esnault

ted a few hundred kilometres further south in the Sine Saloum region. It is therefore possible to envisage the eradication of the population.

## In Burkina Faso, forecasting new invasions

Genetic analyses in Burkina Faso have, on the other hand, revealed that neighbouring populations of tsetse flies are still able to exchange genes along the length of the Mouhoun River, despite much fragmentation of the gallery forests which are their favoured habitat. It appears that these tsetse flies are also capable of crossing the inter-fluves which separate neighbouring river basins such as the Mouhoun and the Comoé. In this region, eradication will therefore be followed by the creation of barriers at the frontiers of cleared zones to prevent new invasions. In the absence of such measures, the speed of

these re-invasions is estimated at 7.5 kilometres per year.

## In Guinea, an island population almost eliminated

In Guinea, an eradication campaign against tsetse flies in the Loos Islands, an archipelago lying off Conakry, followed a genetic and morphometric study. This research proved that the island population of tsetse flies was isolated from those on the mainland. Several anti-vector tactics were used and, in July 2010, not a single fly was found in the Sentinel traps used on the islands. However, this result will need to be confirmed and vigilance is always needed. In these fragmented habitats, tsetse flies survive in the form of metapopulations, with waves of colonisation and extinction.

The next step consists of constructing spatio-temporal models for understanding population dynamics, in order to optimize integrated control of these vectors, combining the use of insecticides (impregnated traps, epicutaneous treatment for livestock) and effective methods for low density populations, such as the sterile male technique. ■

CONTACT > Jeremy Bouyer, Dakar, Emerging and Exotic Animal Disease Control (UMR CMAEE), Philippe Solano, Montpellier, IRD, Host-Vector-Parasite Interactions in Infections by Trypanosomatidae (UMR InterTryp)

**Partners >** Direction des services vétérinaires (Senegal), Institut sénégalais de recherches agricoles (ISRA, Senegal), Food and Agriculture Organization of the United Nations (FAO), International Atomic Energy Agency (IAEA), Centre international de recherche-développement sur l'élevage en zone subhumide (CIRDES, Burkina Faso), Ministères de la Santé et de l'Élevage (Guinea), United States Department of State (United States), Institut de recherche pour le développement (IRD, France)

Bouyer J. et al., 2010. Population structure of *Glossina palpalis gambiensis* (Diptera: Glossinidae) between river basins in Burkina Faso: consequences for area-wide integrated pest management. Infection, Genetics and Evolution, 10: 321-328.



# Health ecology and the management of emerging diseases in Zimbabwe



Taking a blood sample from a buffalo © M. de Garine-Wichatitsky/CIRAD

*Since 2008, researchers at CIRAD and their partners have been monitoring the movements of livestock and wild ungulates on the border of the Gonarezhou National Park in Zimbabwe. Their objective is to better understand and limit the spread of certain diseases. The results achieved are so encouraging that the protocol has been extended to South Africa and Mozambique.*

Raising livestock is one of the main activities in the village communities on the border of the Gonarezhou National Park in Zimbabwe. And yet, as is the case for the majority of protected areas in Africa, the fence marking the edge of the park is either non-existent or in such bad condition that livestock and wildlife frequently cross in either direction to obtain water or to forage. These interactions between wild and domestic animals increase the risk of disease transmission. The team in the Production and Conservation in Partnership (RP-PCP) research platform – one of CIRAD's priority research platforms – has monitored these movements over a period of three years and studied the spread of certain diseases, notably zoonoses.

## Limiting contact between wildlife and livestock

Through this work the research team has demonstrated that bovine tuberculosis has recently appeared in buffalo in Zimbabwe. The absence of barriers and potential contact between wildlife and livestock on the outskirts of the park are a matter of great concern with regard

to the possible spread of the disease to livestock and owners. The consequences it could have, particularly for people who are already immunodeficient as a result of the HIV pandemic, could be disastrous.

## Identifying practices which increase risk

Several surveys of livestock farmers on the fringes of the park have revealed certain practices that could foster the contamination of livestock, such as using pasture and water sources inside the park. Since 2008, six studies have been launched with a view to providing an overview and to monitor pathogens. In parallel with this, 12 buffalo have been fitted with GPS collars in the south-west of the park, alongside 12 cows from 12 herds chosen in an adjacent communal zone. Detailed remote tracking has allowed researchers to characterize precisely their spatial distribution and the movements of wildlife and livestock.

This type of study, based on simultaneous telemetry to monitor wild and domestic animals, is very innovative and its success has persuaded CIRAD and its partners to extend the protocol in neighbouring

**Partners >**  
Centre national de la recherche scientifique (CNRS), University of Zimbabwe, National University of Science and Technology (Zimbabwe), Zimbabwe National Parks and Wildlife Management, South African National Parks (SANParks), University of Pretoria (South Africa), Veterinary services (Zimbabwe, South Africa, Mozambique)

countries around the Great Limpopo Transfrontier Conservation Area (GLTFCA), which includes several national parks: Kruger in South Africa, Limpopo in Mozambique and Gonarezhou in Zimbabwe, and their fringes. ■

**CONTACT >** Michel de Garine-Wichatitsky, Alexandre Caron, Harare, Daniel Cornelis, Montpellier, Animal and Integrated Risk Management

GPS collars make it possible to precisely track cattle movements  
© M. de Garine-Wichatitsky/CIRAD

de Garine-Wichatitsky M. et al., 2010. Bovine tuberculosis in buffaloes, Southern Africa. *Emerging Infectious Diseases*, 16: 884-885.



# Rift Valley fever: what risk for Eurasia?

*CIRAD conducts work on the transmission mechanisms of Rift Valley fever in several countries affected by this disease, but also works in countries not yet affected to evaluate the risk of introduction. Thanks to the networks it has established, it can evaluate the risks of emergence and, above all, propose recommendations for risk management in order to avoid its propagation.*

**R**ift Valley fever is a major emerging zoonotic arbovirus which is rife in continental sub-Saharan Africa, the Indian Ocean, Egypt and the Arabic peninsula. Transmitted either by a vector, mosquitoes, or by direct contact with viraemic material, the disease causes major mortalities in very young ruminants and waves of abortions in pregnant females. In addition to direct economic losses, Rift Valley fever is a major constraint on the movement of live-stock and their products. The diversity of the ecosystems in which the disease is present and the globalization of trade have made Rift Valley fever a global problem.

CIRAD conducts work on this disease in Yemen, where it has analysed the risks of re-emergence, and in Madagascar and southern Africa, where it has studied the maintenance and transmission mechanisms of the virus through the trade

of live animals and in wild animals. In South-East Asia and in Europe, it focuses its work on evaluating the risks of it being introduced, spreading and becoming endemic.

Indeed, the past 20 years have been notable for renewed outbreaks of viral activity with epidemics in Sudan, Madagascar and southern Africa, and a geographical expansion of the disease. Environmental changes and the globalization of trade have played major roles in these outbreaks, and there are fears that the virus will continue to spread into areas which until now have remained unscathed..

This means that South-East Asia is under threat. There is a good deal of trade between the region and Africa, and its climate means mosquitoes which are potential vectors exist throughout the year. Once introduced, there is a risk that the virus could spread rapidly and uncontrollably. It's this introduction

risk which CIRAD evaluates in the framework of GREASE, a priority action which has recently been established. ■

CONTACT > Véronique Chevalier, François Roger, Montpellier, Animal and Integrated Risk Management

**Partners** > Agence nationale de sécurité sanitaire (ANSES), Agronomes et vétérinaires sans frontières (AVSF), National Lyon Veterinary School (ENVL), Centre national de la recherche appliquée au développement rural (FOFIFA, Madagascar), Institut Pasteur de Madagascar, Institut Pasteur de Paris, Institut Pasteur du Cambodge (Cambodia), Institut de recherche pour le développement (IRD), Istituto Zooprofilattico Sperimentale delle Venezie (IZS, Italy), Ministry of Irrigation and Agriculture (Yemen), Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE), Royal Veterinary College (United Kingdom), National agricultural research services (Botswana, Madagascar, Yemen, Zimbabwe), Kasetsart University (Thailand), University of Pretoria (South Africa), University of Sanaa (Yemen)

Abdo-Salem S. et al., 2011. Can environmental and socio-economic factors explain the recent emergence of Rift Valley fever in Yemen, 2000-2001? Vector Borne Zoonotic Diseases. [In press]

Chevalier V. et al., 2011. An unexpected recurrent transmission of Rift Valley fever virus in cattle in a temperate and mountainous area of Madagascar. Plos Neg Trop Dis. [In press]



In Yemen, CIRAD is assessing the risks for the reintroduction of Rift Valley fever. Here, a goat herd from the Horn of Africa has been quarantined

## Emerging diseases: epidemiology in plants, animals and humans

Emerging diseases cause potentially devastating health crises and are a major issue for plant, animal and human health. These diseases, which are hard to predict because of their new and unpredictable character, are the subject in this book of a multi-disciplinary reflection and a specific analysis. Two chapters concern the tropics and were written by CIRAD researchers: one examines Rift Valley fever and one examines bluetongue. These are two of the emblematic emerging diseases from the African continent. Indeed, they are two vector-borne diseases which have been introduced and maintained in certain agroecosystems through the combined effects of climatic, environmental and socio-economic factors.

Barnouin J., Sache I., Les maladies émergentes : épidémiologie chez le végétal, l'animal et l'homme. Versailles, Quae, Coll. Synthèses, 446 p.



# Wildfowl and the transmission of avian influenza in Africa

*The role of wildfowl in the transmission of avian influenza viruses remains poorly understood. CIRAD introduced a programme which integrates information on the ecology of hosts, experimental infections, and remote sensing and satellite telemetry monitoring to better determine their role in the persistence and spread of these viruses.*



© P. Poilecot/CIRAD



Thanks to satellite telemetry, wild ducks can be tracked during migration

© N. Gaidet/CIRAD

**S**urveillance of avian influenza viruses in wild birds has been the subject of considerable efforts on a global scale following the emergence of the highly pathogenic H5N1 virus. However, the role of the ecological interactions between the virus and wildfowl in the transmission dynamics of this zoonosis remain poorly understood. To understand the links between the ecology and epidemiology of this zoonosis, CIRAD introduced a programme which integrates information on the host ecology, experimental infections, environmental monitoring through remote sensing and satellite telemetry monitoring of flights.

## Continual circulation of the virus in wildfowl

Monitoring conducted in Mali and Zimbabwe highlighted, for the first time, a continual circulation of avian influenza in wild bird populations in tropical Africa. Wild ducks seem to play a crucial role in the persistence of these viruses in African ecosystems, similar to the role they play in temperate ecosystems. The modelling of the distribution of these

ducks using remote sensing tools makes it possible to identify and predict the zones and years in which there is a risk of introduction and the transmission of the virus to domestic birds. The existence of an endemic circulation of the virus in tropical Africa is also confirmed by a study conducted at the continental scale. Variations in the prevalence of the viruses, measured in almost 9,000 wild ducks in 15 countries between 2006 and 2009, reveal the influence of several ecological factors, such as bird density (potentially influencing contact rates) and species taxonomy (potentially determining intrinsic receptivity to infection).

## Can migratory ducks disseminate these viruses over long distances?

Following the rapid spread of the H5N1 virus in Asia, Europe and Africa, migratory ducks were quickly suspected. However, while it is true that these birds are capable of long flights and are sometimes found to be infected by virus H5N1, their

CONTACT >  
Nicolas Gaidet,  
Montpellier,  
Alexandre Caron,  
Harare, Animal  
and Integrated  
Risk Management

capacity to disperse the virus remained controversial. Within an international programme coordinated by the FAO, CIRAD conducted a study which made it possible to specify the dispersal potential of these birds. By analysing the range and frequency of the migratory movements of 228 birds of 19 species using satellite telemetry monitoring in relation to the duration of asymptomatic infection, established in experimental conditions, CIRAD has shown that migratory ducks do have the capacity to disperse the virus over long distances (up to 2,000 kilometres on average), but the probability of such dissemination for a given bird is very low (5 to 15 days per year), each bird only rarely travelling long distances.

Gaidet N.,  
Cappelle J. et al.,  
2010. Potential  
spread of highly  
pathogenic avian  
influenza H5N1  
by wildfowl:  
dispersal ranges  
and rates  
determined from  
large scale  
satellite  
telemetry.  
Journal of  
Applied Ecology,  
47: 1147-1157.

This work allows us to better understand the influence of the distribution, abundance and movements of wildlife on infectious diseases. Complementary studies are now underway on the specific role of certain wildfowl species in the transmission of avian influenza virus, and also of Newcastle disease and West Nile virus, with a particular focus on the species which could act as a relay between wild and domestic birds. ■



© P. Poilecot/CIRAD

## line 5 \ **public policy**

Supporting public policies  
aimed at reducing  
structural inequality  
and poverty



## AGREEMENTS, PARTNERSHIPS

**CIRAD was present in Nagoya**, at the UN biodiversity summit. As a user of genetic resources for plant breeding purposes and as a partner of Southern countries, CIRAD is closely involved in these discussions. It also took part in the **United Nations Climate Change Conference** in Cancún, Mexico.

**The Centre d'Analyse Stratégique (CAS)**, which is directly answerable to the French Prime Minister, called upon CIRAD's expertise to inform the debate on two current concerns: the fight against deforestation and the sale of agricultural assets to foreign investors in developing countries. A seminar was organised, and two strategic newswatches and one report published.

**The framework agreement** between CIRAD and the **Conférence des Présidents d'Université (CPU)**, which was signed in April, will enable both establishments to develop their cooperation in higher education, including with establishments in Southern countries.

**Southern Africa** is the subject of an agreement signed in April between CIRAD and the University of Pretoria, which thereby confirm their willingness to develop their partnership. The objective of this agreement is the construction of a centre of cooperation in agricultural and natural sciences and the creation of a platform for regional research on public policy and governance.

**The Mediterranean:** in May, CIRAD signed agreements with two major Egyptian research centres, the Agricultural Research Centre (ARC) and the National Research Centre (NRC), in order to make it easier to set up joint research projects and exchanges between researchers. A convention was signed with the Cultural Office of the Egyptian Embassy in France for the hosting and supervision of young Egyptian PhD students within CIRAD's research units.

## CONFERENCES, PUBLICATIONS, COMMUNICATION

**Addressing price volatility for food security and development:** this seminar was organised in Paris in December by the *Groupe interministériel pour la sécurité alimentaire* (GISA) and the *Groupe de recherche et d'échanges sur la régulation des marchés agricoles* (GREMA), in which CIRAD takes part.

**Perspective**, the series of four-page policy briefs launched by CIRAD in 2009, published four issues in 2010. Fuelling the debate, changing ideas and supporting decisions are the main objectives of this new publication.

**Fair trade** is the subject of a special issue of *Cahiers Agricultures*, a journal supported by CIRAD. Three key concerns are addressed: competition between labels, the real impact of fair trade, and its role in today's economy.

The third conference of the **Outils pour décider ensemble** network, which took place in Montpellier in October, studied and tested the tools and methods that are useful to collective action, including conflict management.

**Spatial Dynamics in Agri-food Systems:** Implications for Sustainability and Consumer Welfare. The international seminar organised by the European Association of Agricultural Economists (EAAE) and the SYAL research group addressed these issues in October in Italy.

Financial services in Ixmiquilpan, Mexico © B. Losch/CIRAD



# Reinvesting in development strategies to address structural challenges

*Agriculture plays a key role in development and poverty reduction. But beyond its production function, it will also need to generate more activities, income and jobs in order to foster rural transformation and structural change. This is the aspect explored by the RuralStruc programme, launched by the World Bank with CIRAD's support, which made a detailed analysis of the socio-economic reality of rural areas in several Southern countries.*

The World Bank *World Development Report 2008* recalled the central role of agriculture in development and poverty reduction. But it also recalled, in reference to past economic transitions, the need for the least competitive producers with the most limited factors of production and human capital to quit agriculture. For these producers, three main options exist: paid farm work, participation in other rural activities as an entrepreneur or an employee, or migration. The RuralStruc programme set up by the World Bank with CIRAD's scientific and technical support explored in detail the socio-economic reality of rural areas in seven countries at different stages of structural change and integration into the world economy.

## Rural household surveys in seven countries

Surveys conducted in rural households made it possible to estimate income levels, and to specify the structure of composite activity systems and the respective levels of agricultural and non-agricultural income. They shed new light on rural poverty and diversification. The findings, marked by considerable differences in local situations, reveal long-term poverty that is particularly severe in sub-Saharan Africa, where per capita income is

well below 2 dollars (at purchasing power parity) per day. In such a context, attempting to ensure food security through food production and own consumption is standard practice. The development of integration and contractualisation processes remains limited and highly localised, and products for sale remain largely confined to traditional trade channels. There is widespread recourse to other rural activities, but this generally involves diversification based on sporadic, poorly paid opportunities that do not represent realistic options for alleviating poverty.

## Employment, the primary challenge for sub-Saharan Africa

Comparing the findings of surveys with the economic and demographic reality of the sub-Saharan African countries revealed the magnitude of the challenges facing these countries, especially that of employment: the number of young people entering the job market every year, estimated at 17 million today, will reach 25 million by 2025, in other words a total demand for employment of around 330 million 15 years from now (equivalent

**Partners >** World Bank, International Fund for Agricultural Development (IFAD), Agence française de développement (AFD), Ministry of Foreign and European Affairs, Ministry of Agriculture, Food and Fisheries (France), Ministry of Agriculture and Facultad Latinoamericana de Ciencias Sociales (Mexico), Ministry of Agriculture and Instituto de Investigación y Desarrollo Nitalapán (Nicaragua), Conseil général du développement agricole and Icon2e (Morocco), Initiative prospective agricole et rurale and Association sénégalaise pour la promotion du développement à la base (Senegal), Ministry of Agriculture and Institut d'économie rurale (IER, Mali), Programme d'action pour le développement rural and APB Consulting (Madagascar), Ministry of Agriculture and Tegemeo Institute (Kenya).



CIRAD is directly involved in surveys in Mali. In this picture, onion growers © S. Fréguin/CIRAD





Small-scale informal trading in Morondova, Madagascar  
© S. Fréguin/CIRAD

to the current population of the United States), including almost 200 million in rural areas.

With 65% of the working population still in agriculture – and up to 80% in some countries –, urbanisation without industrialisation (the informal urban economy absorbs the majority of the non-agricultural workforce) and restricted international migration prospects mean that agriculture will have to play a predominant role. In addition to the production function generally attributed to it, agriculture will also have to generate more activities and income in order to increase effective demand that is essential to rural transformation and structural change.

Proactive policies will need to be implemented with massive investment in infrastructure, training, innovation, market functioning and

regional integration, while ensuring reinvestment in global development strategies, which have long been neglected in favour of insufficiently articulated sectoral approaches. The implementation of territorial approaches, strengthening town-countryside relations and the functions of small rural towns and villages, is one of the main recommendations of the RuralStruc programme. ■

CONTACT > Bruno Losch, Washington, Actors, Resources and Territories in Development (UMR ART-Dev)

Losch B., Freguin-Gresh S., White E., 2010. Structural dimensions of liberalization on agriculture and rural development: A cross-regional analysis on rural change, RuralStruc programme, final report. World Bank, Washington.

<http://www.worldbank.org/afr/ruralstruc>



## The RuralStruc programme

The RuralStruc programme on structural changes in rural economies caused by globalisation is the result of a joint initiative by the World Bank, French Cooperation and IFAD. Launched in 2006 for a four-year period, the programme was backed by a multi-donor fund and supported by three CIRAD researchers, including its coordinator. It involved seven national teams – Mexico, Nicaragua, Morocco, Senegal, Mali, Kenya, and Madagascar – in a two-phase comparative approach (2006-2007 and 2007-2010), aimed at highlighting the diversity of change processes and the ways in which rural households adapt. It used, *inter alia*, surveys conducted among 8 000 households in 26 regions representing the wide range of national situations. In addition to coordinating research, CIRAD was also directly involved in activities in Mali through a consortium with Michigan State University and the *Institut d'économie rurale*. The dissemination of results at the national level, but also among regional organisations and donors, informs the debate on development policies and the specific role of the rural and agricultural sector in structural change in developing countries.

# Regulating through standards: standardisation mechanisms in sustainable development governance

*Long confined to the sphere of responsibility of the public authorities or professional bodies, the development of standards concerning the production and processing conditions for agricultural raw materials is increasingly dependent on the mobilisation of non-State actors. Research conducted by CIRAD highlights the conditions required for this type of regulation to emerge and function at the global level, as well as its impact on producers.*

The standards that define the criteria for producing and processing a product in compliance with the principles of sustainable development are increasingly developed with civil society, or may even be drawn up by non-State actors, such as producers, industries, non-governmental organisations or local communities. Unlike regulations produced by the public authorities, these standards are not legally binding and are the result of a consensus between stakeholders.

CIRAD launched a research programme to gain an understanding of the political and institutional

implications of these standardisation mechanisms. It is based on the study of transnational certification programmes for palm oil and soy, forest certification, the agri-environmental measures implemented at the European level and the information systems set up in France as part of the national biodiversity strategy. These mechanisms are all designed in the name of sustainable development and mobilise a wide range of actors. But, beyond the sector of activity, they are characterised by the intended scale of regulation, their stage of development and their monitoring and enforcement mechanisms.

## Partners >

*Institut du développement durable et des relations internationales (IDDRI), Institut national de la recherche agronomique (INRA), Institut d'études politiques de Paris (IEPP)*

*Djama M., Foulleux E., Vagneron I., 2011. Standard-setting, certifying and benchmarking. A governmentality approach to sustainability standards in the agro-food sector. In: Ponte S. et al. (ed.), Governing through standards: origins, drivers and limits. London, Palgrave.*

*In the forestry sector, certification sometimes exacerbates market segmentation  
© P. Sist/CIRAD*

## Sustainable standards: a political innovation?

The research first focused on the conditions for the emergence of sustainable standards as instruments of public action. It revealed that these standards are part of a long process of internationalisation of agricultural policies and that these instruments, promoted by States and international organisations, are inspired by a neoliberal rationality. The innovations introduced by these standardisation mechanisms involve the increase in stakeholders and the emergence of new moral demands.

## Knowledge mobilisation

The different forums set up as part of these mechanisms have been approached as knowledge networks in which different sorts of learning and worldviews come together. The results reveal the hegemonic role of a type of expertise that favours "auditable" information, reducing environmental and social qualities to indicators and losing sight of the complexity of ecosystems and social relationships. Within this movement, scientific knowledge and local knowledge are subordinate to a management-based expertise, which favours short-term solutions.





## The effectiveness of standards

The efficiency and effectiveness of standards were examined based on the forestry sector, which, due to its anteriority, provided the necessary hindsight for this type of exercise. The evolution of the market for certified products shows that certification only applies to a minority of sensitive consumers in European and North American countries. On local markets in developing and emerging countries, where there is exponential growth in demand for wood, responsible consumption is absent, or at most very limited. Thus, instead of a having positive knock-on effects for the least environmentally-friendly modes of production, sustainable standards sometimes make the market even more fragmented by maintaining niches for the most virtuous products.

The effectiveness of standards was also measured in the forestry sector in terms of its political impact. First, standardisation mechanisms create forums for discussion, which foster learning and conflict resolution. Standards also have an influence on debates and policies at the international and national levels. For example, the discourse on the rights granted to local populations within the framework of forest certification schemes influences national legislative processes and international negotiations on forests. The integrative effect of standards is seen in the way in which voluntary private regulation mechanisms are included in public policy measures, and, vice versa, in the way in which public policies may find a basis for implementation through standards and certification. ■

CONTACT > Marcel Djama, Montpellier, Markets, Organizations, Institutions and Operators' Strategies (UMR MOISA).

## Renewing approaches to innovation: the ISDA 2010 symposium



© G. Serpantié/IRD

Organised by CIRAD, INRA and Montpellier SupAgro, the international symposium on Innovation and Sustainable Development in Agriculture and Food (ISDA 2010) brought together more than 500 participants from 65 countries from 28 June to 1 July in Montpellier. With 300 presentations, a comprehensive overview of the problem was presented. The debates, which focused on the capacity of agricultural and food systems to innovate, raised new questions. If the concept of a system of innovation is relevant to understanding innovation as a process of interaction, it seems necessary to find ways to better understand this interaction: who are the new actors involved? Who

plays the role of mediator? How do knowledge hybridisation and learning take place? How can coordination between these different actors be encouraged? What role should research play? It is by asking these questions that new approaches to innovation can be developed in order to better meet the challenges of sustainable development.

CONTACT > Emilie Coudel, Montpellier, Innovation and Development in Agriculture and the Agrifoods Sector (UMR Innovation).

Coudel E., Devautour H., Soulard S., Hubert B. (eds.), 2010. Innovation and sustainable development in agriculture and food: Proceedings of the ISDA symposium, Montpellier, France, [hal.archives-ouvertes.fr/ISDA2010](http://hal.archives-ouvertes.fr/ISDA2010)  
[www.isda2010.net](http://www.isda2010.net)

## Innovating with the rural actors: action-research partnerships

Action-research partnerships combine knowledge production, the transformation of social realities and individual and collective capacity building. Such an approach renews research practices to establish partnership relations with rural actors (producers, field advisers and technicians, and representatives of farmers' organisations, etc.). For several years, CIRAD researchers have been working on this approach, which was presented and discussed during different training and knowledge-sharing workshops in Africa. These workshops made it possible to launch several action-research partnership projects locally, especially in Cameroon and Burkina Faso.



A book published in 2001 summarises these discussions. It presents the basis of this approach and elements for putting it into practice. It underlines not only the theoretical questions, but also the practical questions it raises. The book is based on a wide range of experience in agriculture in Southern countries, which illustrates how practitioners have responded to the challenges of an approach that must be constantly reinvented according to the context.

Faure G., Gasselin P., Triomphe B., Hocdé H., Temple L. (ed.), 2010. Innover avec les acteurs du monde rural : la recherche-action en partenariat. Versailles, Quae, 221 p.

# The law of geographical indications: India's experience

*Geographical indications are distinctive signs that provide a means of enhancing the value of the natural resources of a place and the know-how of its population. Indian law on the matter raises several questions regarding the validity of geographical indications that are based on know-how alone in the absence of natural factors, the role of the State in their protection, and their legal nature. Hence the idea of rejecting the concept of property to adopt that of rights of use of a common good, a qualification that applies to many of the countries in which CIRAD is active.*

India, an emerging country with a long history, is endowed with many regional products and has set up a unique legal framework to protect its geographical indications, shedding new light on the concept of the link between a product and its origin. The law, which protects both handicrafts and traditional plant varieties – the reflection of Indian cultural identity – is a response to the threat of globalisation. But this experience calls into question French and European law as regards the recognition of traditional knowledge in the absence of natural factors to justify local origins, while confirming the value of geographical indications as a means of protecting the diversity of heirloom plant varieties. Debates on handicrafts extend well beyond India, finding an echo in all Southern countries as well as in Europe, and question the principle of a legal system with identical protection whether or not natural factors are present.

## The Indian model

The omnipresence of the Indian State in the protection of geographical indications contrasts with the withdrawal of public intervention in France linked to the context of economic liberalisation. The Indian government's intervention, which results in the registration of geographical indications in the name



Tea plantation in India © D. Marie-Vivien/CIRAD

of the State, is justified by the protection of disadvantaged producers and the need to preserve the products of the Indian identity.

## Rights of use or property

The Indian model has two subjects of law, with on one side the owner of geographical indications, the representative of producers, which

proves to be directly or indirectly the State, and on the other side the producers who are users of these indications, and questions the legal nature of geographical indications, whether the fact that they are collective or that they belong to public law. In view of Indian experience, where this property model does not permit sufficient accession by users, while the model of property is evaded in Europe, it is proposed that a geographical indication should be qualified as a right of use of a common good, and that the principle of property should be rejected. The question of the role played by the State in the implementation of this right – a State whose solidity and transparency are changeable – appears as a cross-cutting, crucial one in view of its omnipresence, whatever the system.

This research provides new insights into the geographical indication projects in which CIRAD is involved and for which it provides expertise, in West Africa, South America and Asia, concerning the intellectual creations in question, both agricultural and non-agricultural, or the most appropriate institutional mechanisms to put in place. ■

CONTACT >  
Delphine  
Marie-Vivien,  
Montpellier,  
Innovation and  
Development in  
Agriculture  
and the Agrifoods  
Sector  
(UMR Innovation)

Marie-Vivien D., 2010. The role of the state in the protection of geographical indications: From disengagement in France/Europe to significant involvement in India. *The Journal of World Intellectual Property*, 13 : 121-147. Doi : 10.1111/j.1747-1796.2009.00375.



# How do States formulate their sustainable rural development policies?

*The concept of sustainable rural development, which was introduced at the international level some 20 years ago, has been largely taken up by public managers at the national level.*

*But how can States that are very different – in terms of wealth, productive capacity, natural resources, etc. – implement the same precepts with equal success? This is the question the PROPOCID project, launched in 2007 by CIRAD, INRA and GEMDEV, attempted to answer.*

The aim of the PROPOCID project was to understand how sustainable rural development policies are actually developed, given the specificities of national contexts – the level of wealth, the structure of the productive system, the type of natural resources, administrative capacity, history and traditions, etc. More specifically, the objective was to analyse the integration and assimilation of sustainable development in national public policies.

This study is based on a comparative analysis of agricultural policies in countries with very different situations: emerging countries (Brazil, Mexico), an industrialised country (France), an EU outermost region (New Caledonia), and less economically developed countries (Mali, Madagascar). The aim was

first to study antecedents and the role of sustainability in the development paths of each country, then to understand the methods for introducing sustainability at the national level and the national development policy-making process, and finally, to analyse the methods for applying these policies.

The findings highlight the key role of economic liberalisation and State competitive integration processes during the 1980s and 1990s in the capacity for public intervention at the national level, and therefore in the implementation of sustainable rural development. The countries with the most limited resources are, for the most part, obliged to hand over the management of sustainable development to external operators, whereas for the two emerging countries, sustainability is a chal-

lenge for the socio-territorial reorganisation of the agricultural sector. In France and New Caledonia, sustainable development does not make any significant contribution in relation to past development practices and current challenges. It is also clear that by legitimising the duality of agriculture, which attributes different functions to the entrepreneurial and family sectors, sustainability has a structural effect on certain national agricultural systems. Moreover, due to the sectoral nature of the policies implemented, the main institutional innovations concern the articulation and territorialisation of public policies. ■

Contact > Philippe Bonnal,  
Actors, Resources and Territories  
in Development (UMR ART-Dev)

**Partners >**  
Groupement  
d'intérêt scientifique  
pour l'étude de la  
mondialisation et du  
développement  
(GEMDEV),  
University of  
Paris-Sud, Institut  
national de  
la recherche  
agronomique (INRA),  
Federal Rural  
University of Rio de  
Janeiro (UFRRJ,  
Brazil), Centro de  
Investigaciones y  
Estudios Superiores  
en Antropología  
Social (Ciesas,  
Mexico), Institut  
d'économie rurale  
(IER, Mali),  
University of  
Bamako (Mali), Ecole  
Supérieure des  
Sciences  
Agronomiques (Essa,  
Madagascar),  
University of  
Antananarivo  
(Madagascar),  
Institut agronomique  
néo-calédonien  
(IAC), University  
of New Caledonia,  
Agence nationale  
de la recherche (ANR)



Bonnal P. et al.,  
2010.  
La production  
des politiques  
et compromis  
institutionnels  
autour du  
développement  
durable. Final  
report of the  
PROPOCID  
project. Paris,  
ANR.

# Rural council management, community management and local development

*For the last 15 years, political decentralisation and its corollary, the transfer of forest resources management from the State to local communities, have been underway in Mali, Niger and Madagascar. Since 2007, a research and development project coordinated by CIRAD has been focusing on these processes and the links between them. Its aim is to provide simple, reproducible solutions to improve the functioning of commodity chains and the income of populations and to ensure these forests become profitable areas that are managed in the long term.*



Developing new production activities such as essential oils in Madagascar  
© P. Montagne/CIRAD

## Partners >

Agence pour le développement de l'électrification rurale (Ader, Madagascar), Centre national de la recherche appliquée au développement rural (Fofifa, Madagascar), Participation à la gestion de l'environnement (Partage, Madagascar), Agence malienne pour le développement de l'énergie domestique et l'électrification rurale (Amader), Institut national de recherche agronomique du Niger (Inran), Groupement d'experts pour le développement urbain et rural (Gedur, Mali), Bureau d'experts en autogouvernance et gestion de l'environnement au Sahel (Beagges, Mali), ABC écologie (Niger), European Union.  
[www.gesforcom.eu](http://www.gesforcom.eu)

as essential oils in Madagascar, or existing, such as charcoal, raffia and timber in Madagascar, gum arabic and fuelwood in Niger, and timber in Mali. The aim is to promote biodiversity in a sustainable manner and to alleviate poverty. In Madagascar, for example, two decentralised rural electrification units will be installed to supply a sawmill and drying unit, which will increase the value of timber by producing better quality products of first stage processing. These steam engine generators will also use local biomass such as plant waste and rice hulls.

## Rural council and community management policy

The project team also worked to draw up rural council and community forest development plans, and set up environmental monitoring systems to guarantee the sustainability of forestry practices. This forest management policy is aimed at conserving resources through their controlled commercialisation, with harvesting quotas that respect the capacities of ecosystems and increase the economic value of products. This is the only

**T**he GESFORCOM project (Rural council management, community management and local development: towards the decentralised joint management of forest resources) analyses the linkages between political decentralisation and the transfer of forest resources management from the State to local communities. In partnership with people involved in research and development in Niger, Mali and Madagascar, CIRAD, which coordinates this project with the support of the

European Union, has thus been able to define the methods for the sustainable, stable and profitable management of the forest resources in these countries, shared between rural councils and local communities.

## Making better use of forest resources

The first part of the project concerns the development of productive activities, whether new, such



policy capable of guaranteeing the future of rural populations.

The project is also based on training for all the actors in the system, from loggers, gatherers and charcoal makers to carriers, merchants, and rural council and forest administration officials. These training courses adapt knowledge and know-how, and in so doing help to increase sawn timber output (from 10 to 20%) or to improve the transformation of wood into charcoal. The quality of products such as gum arabic, essential oils and raffia is also considerably improved, which increases the prices paid to primary producers and encourages them to comply with the forestry standards and rules set out in the development plans.

## Management transfer contracts and ecosystems

The team also examined the repercussions of management transfer contracts on the sustainable management of ecosystems. The studies conducted in the dry forests of Western Madagascar and Niger indicate that it is possible to improve the sustainable management of these forests by promoting their multifunctional nature. In general, although these contracts have a positive impact on poverty reduction and on the appropriation of resources by villagers, they also result in imbalances in the dynamics of socio-ecosystem functions. Attributing other values to trees

and forest ecosystems than those linked to the production of fuelwood should help to restore the balance of these functions.

Finally, communication is a key element of the project. All of the findings are disseminated among actors in the form of leaflets in the national languages, brochures and books. The aim is to provide simple, reproducible solutions to improve the functioning of commodity chains and the income of populations so that forests are no longer seen as unlimited areas for gathering, or even illegal logging, but rather as areas that can provide long-term profits. ■

CONTACT > Pierre Montagne, Antananarivo, Tropical Forest Goods and Ecosystem Services

Training climbers to collect *Ravensara aromatica* leaves, Madagascar © V. Razafiaritiana







Date harvest, Tunisia  
© O. Hébrard

## line 6 \ rural areas

Understanding the relationships between nature, agriculture and society better so as to manage tropical rural areas sustainably



## AGREEMENTS, PARTNERSHIPS

**ALLENVI, the Alliance for the environment (food, water, climate, regions)**, is the fourth French research alliance after the alliances for health (AVIESAN), energy (ANCRE) and digital technology (ALLISTENE), and is aimed at creating synergies between 12 actors involved in scientific research, including CIRAD.

With the **Center for International Forestry Research (CIFOR)**, an agreement continues cooperation on the issues of deforestation and climate change.

In order to identify **research priorities** of mutual interest to Europe, Africa, Latin America and Southeast Asia, CIRAD organised the first workshop bringing together the three INCONET (International Cooperation Network) projects in which it is involved on the subject: Food security and adaptation to climate change in Southern agriculture.

In **Mayotte**, CIRAD and the TETIS joint research unit provided the departmental council with a new inventory of woody vegetation (trees, shrubs and creepers). The operation took part within the framework of the Mayotte forest typology project, financed by the European Development Fund (EDF).

**Agriculture and sustainable development:** This conference presented the results of the 18 projects carried out as part of the cross-cutting programme on "Agriculture and sustainable development" supported by ANR, ADEME, CEMAGREF, CIRAD, INRA and IFREMER in Paris in December.

## CONFERENCES, PUBLICATIONS, COMMUNICATION

**Biodiversity** was top of the agenda in 2010. Special events throughout the year and during the science festival underlined CIRAD's major contribution to this field, especially in the French overseas departments and territories. Several CIRAD researchers were approached by the media, and a debate was organised at Agropolis. A web site, videos and several publications were produced. For the 4<sup>th</sup> edition of the **Ciné-Science scientific film festival** in Languedoc-Roussillon (March-April), CIRAD, one of the organisers, presented two films in competition: *Yiriba, des sources de vie au Mali* and *Baobabs entre ciel et terre*. The latter received the silver trophy at the CinéScience festival in Réunion in April. In terms of research, the *Bois et forêts des tropiques* journal, published by CIRAD, produced several special reports on biodiversity, non-wood forest products, and dry forests.



**African ecosystems absorb more carbon than they emit.** This observation is one of the main findings of the European CarboAfrica project. For more than three years, 14 European partners, including CIRAD, examined the continent's carbon cycle.

**Understanding and managing tropical ecosystems:** this conference was organised in Montpellier in December as part of the ECOFOR research programme on tropical ecosystems.



The *Académie d'Agriculture de France* Clément Jacquot prize was awarded to Michel Arbonnier for his reference work, *Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest*.

As part of the GFAR (Global Forum for Agricultural Research) **Global Conference on Agricultural Research for Development**, held in Montpellier in March, CIFOR, CIRAD and IRD organised a seminar: *Taking stock of small-holder and community forestry: Where do we go from here ?*

LandMod 2010, the **International Conference on Integrative Landscape Modelling**, held in Montpellier in February, was organised by Agropolis Fondation, CIRAD, the Global Land Project, INRA and the *Réseau national des systèmes complexes*.

In terms of **scientific and technical information and rural development**, practices reveal that farmers themselves are using all possible means to gain access to technical information. The conference was organised in April by the International Association of Agricultural Information Specialists (IAALD), Agropolis International, CIRAD, IAMM, INRA and Montpellier SupAgro.

**The role of livestock farming in rural areas** was the subject of a special edition of *Cahiers Agricultures*, a journal published by CIRAD. This edition was coordinated by two experts from CIRAD and INRA.

The **International Commission on Irrigation and Drainage (ICID)** held its 24<sup>th</sup> European conference, Groundwater 2011, in Orléans in March. CIRAD was a partner of the event, with the *Association française pour l'étude des irrigations et du drainage* (AFEID).



# Woody biomass decay in a French Guianan forest

*Deadwood can account for up to 40% of total above-ground biomass in tropical forest systems. The dynamics of this biomass decay are, however, poorly understood. Using the network of forest plots in Paracou, French Guiana, a team from CIRAD launched an extensive study on wood decay for 26 forest species. It was thus able to develop simple decay models, based on three variables: the age at death time, the diameter of the dead tree and the density of its wood.*

**F**orests, which represent 80% of above-ground biomass, play a key role in the global carbon cycle. Tropical forests alone are responsible for about 35% of the planet's primary production, and deadwood is an essential component of this cycle, with almost 40% of the total biomass of trees. However, the kinetics of this deadwood decay are poorly understood, leading to uncertainty in global carbon cycle models. Using the permanent plot network in Paracou, French Guiana, CIRAD was able to study the parameters of this decay and to propose explanatory models.

## An exceptional research station

The Paracou station includes nine 6.25 hectare plots that were established in 1983. With more than 550 species identified in these plots, two dry spells per year and annual rainfall of more than 3 m, the Paracou forest is typical of French Guianan forests. Inventories, which were yearly until 1995 and then every two years from then on, record the mortality and circumference of all individuals present with a diameter at 1.30 m height of over 10 cm.

Thanks to the database provided by these 23 years of inventories, the researchers were able to collect and then measure the remaining fraction of boles from 367 dead trees from 26 species. The wood from these species has a wide

range of densities, from 0.23 to 1.24 (at 12% humidity), and circumference at death time ranges between 31.5 and 272.0 cm.

## Modelling the decay rate

The decay rate was then modelled. In addition to the age at death time, the diameter of the trunk at death time and the density of the wood, the effect of several environmental variables was tested: the type of forest management (selective logging or unexploited), the mode of death (standing or downed), and the topographical level (bottomlands or hilltops).

The decay models selected explain up to 60% of variability by simply taking as variables the age at death time, the diameter of the tree at the time of death and the density of its wood. Neither forest management nor topography have a significant impact on the wood decay rates. Whether the dead trees are standing or downed has only a very limited effect on the model.

Overall, these results suggest that the release of carbon from tropical dead trees to the atmosphere can be estimated using three variables: the tree circumference at death time, its age and the density of its wood. ■

CONTACT >  
Jacques  
Beauchêne,  
Kourou, Ecology  
of the Forests of  
French Guiana  
(UMR ECOFOG)

Hérault B. et al.,  
2010. Modeling  
decay rates of  
dead wood in a  
neotropical  
forest. *Oecologia*,  
164: 243-251.  
Doi: 10.1007/  
s00442-010-  
1602-8

For certain hollow species (left), heartwood decay begins while the tree is still alive, as with *Vouacapoua americana*. For many trees, wood decay begins after the death of the tree, in the peripheral part, beginning with the sapwood, and gradually spreads to the central part of the trunk, the core, as with *Eperua grandiflora* (right)  
© F. Muller/CIRAD





# When family farming protects the Amazon rainforest

*Protecting forests within small farms while improving the standard of living for farmers was the main objective of a project coordinated by CIRAD in the Brazilian Amazon. With output three times higher than the regional average, the crop management techniques proposed have proven their effectiveness, and the long-term management of the forest can now be envisaged. The challenge now is to promote these production models so that they can be adopted on a large scale.*



The Trans-Amazonian highway © P. Sist/CIRAD

During the colonisation of the Brazilian Amazon, which began in 1970, each family of farmers was granted a plot of land along the new highways. The colonists were given permission to clear between 20 and 50% of their land, with the rest to be kept as forest. But, due to a lack of appropriate techniques, the land cleared quickly lost its fertility and the best alternative for farmers was to convert cropland to pastures. After a few years, the properties were entirely deforested, and the pastures became unproductive due to the loss of soil fertility. Most often, the farmers abandoned their properties and migrated to new areas to start the process over again.

To break this cycle, the FLOAGRI project [*Floresta e agricultura*] was launched by CIRAD and its Brazilian partners in 2005 with European Union funding. Its objectives were to test and validate crop management techniques that reconcile agriculture and forest management. After four years of activity, the results are very positive.

## Output three times higher than the regional average

In Brazil, around 12 farmers took part in the project. The aim was for them to set up permanent agricultural plots of 1 to 2 hectares of

CONTACT >  
Plinio Sist,  
Montpellier,  
Tropical Forest  
Goods and  
Ecosystem  
Services

food crops (maize, rice) by adapting direct seeding mulch-based cropping systems to the humid tropical climate. With a productivity of 3 to 5 tonnes per hectare of rice or maize compared to a regional average of 1 to 2 tonnes, the results are particularly encouraging and show that it is possible to grow food crops in the Amazon without clearing forest and with sustained output. Although investment is needed to set up this kind of system, it does not exceed the loan amounts provided by credit programmes for family farming.

## Partnerships for sustainable forest management

The project team also accompanied three forest management plans, enabling it to better understand the conditions under which forestry operations could be viable, from an economic and environmental viewpoint, for family farming. Under current conditions, the financial and technical means available to farmers for implementing sustainable forestry practices themselves on their properties are still very limited. Legal requirements remain oriented towards large-scale forest development and pay little attention to the specificities of small-scale community forest management. The approval process for forestry operations is often a long one, taking two to three

Partners >  
*Empresa Brasileira de Pesquisa Agropecuária* (Embrapa, Brazil), *Instituto de Pesquisa Ambiental da Amazonia* (Ipam, Brazil), Ministry of Environment (Brazil), *Fundação Viver Produzir Preserva* (FVPP, Brazil), University of La Selva (Unas, Peru), *Instituto Nacional de Investigaciones Agropecuarias* (Iniap, Ecuador)

years, and many farmers give up along the way. Finally, market prices remain very low in relation to operating costs: 60 dollars per cubic metre for inventory costs and almost 50 dollars for logging. One solution for farmers is to establish partnerships with forestry companies. Agreements of this kind have already been reached in the region, but they are uncommon.

Although the results of permanent agricultural plots are promising, research on soil fertility and reducing fertilisers continues. Forestry operations can play a key role in the establishment of sustainable forestry systems through the sale of timber, but the true role of this forest income in farmers' strategies remains to be determined. Finally, production models must obtain the support of institutions to be adopted at municipal or regional level. Without a public policy to support these technical innovations, these models will be unable to spread. The survival of family farming and the protection of the Amazon rainforest depend on this. ■

# Mycorrhizal fungi, partners in the adaptation of plants to their environment

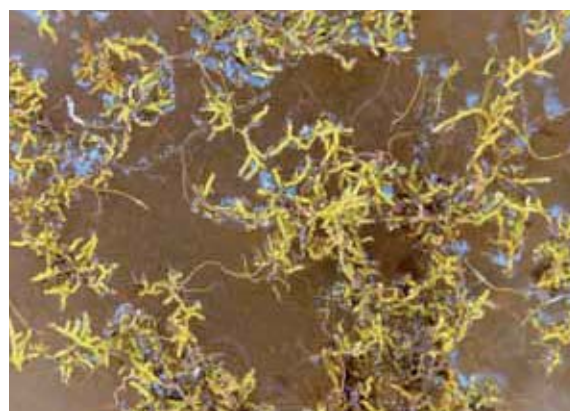
*The soils of New Caledonia provide extreme conditions for life.*

*Their heavy metal content, their lack of nutrients and their imbalanced composition would make them some of the most toxic soils if they were not natural. Diversified forests and scrubland vegetation nevertheless grow there. The plants have their own ways of adapting to these constraints, but the mycorrhizal fungi associated with them also enable them to better tolerate these constraints, as a CIRAD team recently demonstrated.*

Due to the particular metalliferous nature of its soils and its geographical isolation, New Caledonia is a veritable laboratory for studying plant adaptation to abiotic constraints. Thus, in soils that would be considered highly toxic if not natural, some of the most diverse forests and scrubland vegetation in the world grow spontaneously. Several plant adaptation strategies to these constraints have been recorded: hyperaccumulation of toxic metals in leaves or sap, as with *Sebertia acuminata*, for example, and the formation of specialised roots in Proteaceae. Research conducted by CIRAD has recently shown that mycorrhizal fungi also played an important role in this adaptation.

## Mycorrhization, a response to soil toxicity

The Cyperaceae endemic to New Caledonia constitute, in the absence of native grasses, the only herbaceous layer in scrubland in



Natural ectomycorrhizas of *Pisolithus albus* in symbiosis with *Tristaniopsis guillainii*, metalliferous soil in the Koniambo range, New Caledonia  
© M. Ducouso/CIRAD

metalliferous soils. These species, unlike other Cyperaceae, often form symbiotic associations with arbuscular mycorrhizal fungi, which play an important role in plant survival and growth. This mycorrhizal ability also protects them against nickel by considerably reducing the transfer of this metal to the leaves.

## Increased tolerance to nickel

The Myrtaceae, especially *Tristania* spp., also form ectomycor-



Tree for timber in the forest plot of a farmer in the Trans-Amazonian highway region, *Manilkara huberi* (Sapotaceae) © P. Sist/CIRAD



rhizal symbioses on their roots with numerous fungi. Among these, the New Caledonian populations of *Pisolithus albus*, a species that is also found in Australia and New Zealand, and is very widespread in the tropics among the eucalyptus, are structured in ecotypes according to the area they come from. In New Caledonia, strains from metalliferous soils have a very high tolerance to nickel, at around 1 600 micromolar, or 400 times the dose tolerated by strains from other areas, which are all sensitive to very low doses of soluble nickel. Attempts at mycorrhizal colonisation were conducted with one of these strains on a eucalyptus of the species *Eucalyptus globulus*, an exotic species in New Caledonia that is naturally sensitive to nickel. The eucalyptus

proved to be 10 times more nickel-tolerant than those colonised by a sensitive mycorrhizal strain. Once again, this tolerance is accompanied by a spectacular reduction in nickel transfer from the roots to the above-ground plant parts.

This research shows that mycorrhizas contribute considerably to the adaptation of the host plant and find a field of application that goes well beyond the revegetation of mining sites in New Caledonia. They present opportunities for using mycorrhizal symbiosis in the adaptation of plants to their environment. ■

CONTACT > Marc Ducouso, Montpellier, Laboratory of Tropical and Mediterranean Symbioses (UMR LSTM)

Jourand P. et al., 2010. Ultramafic soils from New Caledonia structure *Pisolithus albus* in ecotype. FEMS Microbiology Ecology, 72: 238-249.

Fructification of *Pisolithus albus* in *Tristania* spp. scrubland on metalliferous soil in the Koniambo range, New Caledonia © M. Ducouso/CIRAD



## Awards for the Biotik software

The software for identifying tree species in the forests of the Western Ghats of India received the first prize from the Bioinformatics Centre, Pondicherry University, as well as the Manthan Award South Asia in the e-environment category. This application, based on the IDAO software for species identification, was developed by CIRAD and the French Institute of Pondicherry, as part of a European project. It is a multimedia application for the identification of species that provides a botanical and ecological description of woody species in English and also in local languages. This software is aimed at researchers and students, foresters and taxonomists, who will be able to use it for forest management and conservation purposes. India's Manthan Award goes to the best innovations in terms of digital content and creativity. The first prize of the Bioinformatics Centre, Pondicherry University, was awarded during a conference on recent trends in structural bioinformatics and computational biology.

CONTACT > Pierre Grard, Hanoi, Botany and Computational Plant Architecture (UMR AMAP)

**Partners** > French Institute of Pondicherry, (India), Leiden University (Netherlands), National University of Laos, European Commissions (Asia IT&C Programme

[www.biotik.org](http://www.biotik.org)

Pierre Grard (left) with Dr. Ramesh B.R. of the French Institute of Pondicherry, receiving the award and the trophy © J. Nagarajan



# Architectural diagnosis and maturity of French Guianan forests

*Tropical forests play a fundamental role in climate regulation by accumulating biomass. However, without precise data on forest ecosystems, it is impossible to draw conclusions about the causes of this accumulation: is it a natural process linked to tree mortality or the result of global environmental factors? At the Paracou research station in French Guiana, CIRAD has established a architectural diagnosis of trees enabling it to predict their mortality and to determine the maturity of stands.*

By capturing large quantities of carbon, tropical forests play a key role in climate regulation. Anthropogenic disturbances could seriously affect carbon sequestration in these forests. In the Amazon, changes have been observed over the last few decades in the structure and dynamics of forest ecosystems that are apparently unaffected by human activities. This forest also accumulates biomass, on average 1.22 tonnes per hectare per year, thereby acting as a carbon sink. The lack of knowledge about the

forest ecosystem makes it impossible to draw unambiguous conclusions about the causes of this accumulation.

An extensive study was conducted at the Paracou forest research station, which was set up by CIRAD in 1984 in French Guiana. This station includes six permanent plots of 6.25 hectares each, in which all trees of over 10 cm in diameter are mapped, identified and regularly measured. Three of these plots accumulate significant biomass, and mortality plays a vital role in this process. Mortality varies from one period

Partner >  
GUYAFOR project

CONTACT >  
Eric-André  
Nicolini, Kourou,  
Botany and  
Computational  
Plant  
Architecture  
[UMR AMAP]

to another, without any synchronism between the permanent plots, excluding for the time being the influence of specific climate events in French Guiana.

Tree mortality, determined by the maturity of stands, is a major element in the dynamics of stands. This maturity was first established using a simplified structural description of more than 3000 trees. Based on the structure and the degree of fragmentation of the tree crowns, the structural diagnosis takes into account the wide range of crown shapes. It also makes it possible to identify trees with declining growth and to improve mortality predictions. Finally, the structural diagnosis contributes significantly to defining different relevant forest stages. These stages help to reconstruct the forest mosaic of permanent plots and shows that the differences in carbon balances observed in fact correspond to forest stands that have reached different stages of maturity. ■

Rutishauser, E., Wagner, F., Hérault, B., Nicolini, E., Blanc, L., 2010. Contrasting above ground biomass balance in a Neotropical rainforest. *Journal of Vegetation Science*, 21.

Rutishauser E., Blanc L., Nicolini E., 2011. Crown fragmentation assessment in tropical trees: method, insights and perspectives. *Forest Ecology and Management*, 261 : 400-407.

The tropical forest canopy in French Guiana  
© E.A. Nicolini/CIRAD





# Farmers and the modernisation of irrigation schemes in Tunisia

How do farmers perceive the modernisation of their irrigation system? This is the question asked by a CIRAD PhD student as part of the SIRMA project on water management in irrigation systems in the Maghreb. This original analysis starts from the premise that irrigation programmes are usually based on technical and economic considerations without substantial involvement of their beneficiaries. By investigating farmers' discourse, practices and expectations and comparing these with the technical solutions implemented by engineers, the study provides insights into the limitations of each approach, that of experts and that of farmers, and supports the advantages of combining both viewpoints. It took place during the modernisation programme for the irrigation and drainage system in the Fatnassa oasis in southern Tunisia.

**CONTACT >**  
Serge Marlet,  
Tunis,  
Water Resource  
Management,  
Actors and Uses  
(UMR G-EAU)

**Partners >** *École nationale du génie rural, des eaux et des forêts (ENGREF), Institut de recherche pour l'ingénierie de l'agriculture et de l'environnement (CEMAGREF), Institut national de recherche en génie rural, eaux et forêts (INRGREF, Tunisia)*

This recently published research has just received the Best Paper Award from the Journal of Irrigation and Drainage. Its author also received the Henri Tardieu award from the *Association française pour l'eau, l'irrigation et le drainage* (AFEID). These awards recognise the efforts of all the Algerian, Moroccan, Tunisian and French partners of the SIRMA project.

Ghazouani W. et al., 2009. Farmers' perceptions and engineering approach in the modernization of a community-managed irrigation scheme. A case study from an oasis of the Nefzawa, South of Tunisia. *Irrigation and Drainage, Supplement: Irrigation Management in North Africa*, 58: S285-S296. Doi: 10.1002/ird.528

## SIRMA, a partnership-based skills network in the Maghreb

The SIRMA network, one of CIRAD's priority research networks in the Mediterranean, perpetuates and extends the relations developed as part of the SIRMA research and training project launched in 2004 within the framework of the Fonds de solidarité prioritaire (French priority solidarity fund). With the professional agricultural sector, it develops technical innovations, economic tools and institutional mechanisms to improve agricultural water management. It also conducts research, training and exchange activities in the Maghreb, in cooperation with French and European teams. One of its priorities is to train young researchers from the Maghreb and to promote their work.

<http://www.eau-sirma.net>



The Fatnassa oasis, in southern Tunisia, is faced with salinity © S. Marlet/CIRAD

# Sharing water resources in the rice-growing region of Klaten, Indonesia

*The agricultural region of Klaten is one of Indonesia's main "rice baskets". In irrigated areas, smallholders grow two or three rice crops per year. Since the 1990s, they have increasingly struggled to grow off-season crops due to water scarcity caused by non-agricultural withdrawal, and conflicts are emerging between users. CIRAD, with its Indonesian partners, intervened in the Pusur basin to ease tensions and to launch the collective development of an integrated and participatory plan of action.*



Irrigation canal in the Klaten region © J. M. Lopez/CIRAD

In the downstream part of the Pusur river, surface water resources are shared between 12 000 small rice producers and two water companies: a public company supplying the city of Solo, and Danone-Aqua, a private company producing bottled water. The companies were blamed for agricultural water scarcity in the dry season (June-October) by farmers and local NGOs. Conflicts emerged between farmers' groups due to water theft and non-compliance with irrigation schedules, before spreading to the water companies.

CIRAD was called upon to attempt to resolve these conflicts and to develop an intervention approach that reconciles stakeholder preferences in terms of action while ensuring more equitable access to water.

This approach, which was developed between 2006 and 2009, is based on the integration of information on water resources (and their uses), a change of scale (from the irrigated scheme to the whole watershed) and knowledge sharing. It uses multi-stakeholder platforms,

**Partners >**  
Danone-Aqua (Indonesia), Indonesian Agroclimate and Hydrology Research Institute (Iahri, Indonesia), University of Yogyakarta (Indonesia), Klaten regional authority, Klaten water and agriculture technical services.

community workshops, monitoring committees and modelling tools. It involves four stages: a series of participatory workshops to compare stakeholder opinions about the water scarcity and its causes; a participatory appraisal associated with a results feedback-discussion workshop to foster a global, shared vision; the translation of this vision into the collective development of a plan of action at the level of a pilot area, through interactive modelling workshops; and the creation of a water management body, which managed the first improvement initiatives in the area.

Given the encouraging results, all of the Pusur stakeholders requested that the approach tested in the pilot area be extended to the whole basin. CIRAD proposed a plan of action for implementation in 2011-2013. This plan was adopted by the stakeholders. ■

**CONTACT >** Bruno Lidon, Jean-Marie Lopez, Montpellier, Water Resource Management, Actors and Uses (UMR G-EAU)

Lopez J.M., Bourgeois R., Lidon B., Brault Y., Kartiwa B., Sosiawan H. 2011. From conflict to equity: handling the challenge of multipurpose use of ground and surface water in Indonesia. In: *CIID. Groundwater conference 2011 : gestion des ressources en eaux souterraines*. 14-16 March 2011, Orléans, France.

[http://www.groundwater-2011.net/var/groundwater\\_2011/storage/original/application/ppt/Topic3.pdf](http://www.groundwater-2011.net/var/groundwater_2011/storage/original/application/ppt/Topic3.pdf)



# The greening of the Sahel: natural vegetation dynamics or land use change?

*In the Bani catchment area in Mali, an increase in the vegetation index has been observed by remote sensing over the last 25 years. This greening, which has been seen in most of the studies conducted in West Africa, is not accompanied by any significant increase in rainfall.*

*So how can this trend be explained? According to a team from CIRAD, it may be the result of natural vegetation dynamics rather than of land use changes, as is often suggested.*

In the Bani catchment area, which covers 130 000 square kilometres in Mali, a team from CIRAD and its partners monitored vegetation dynamics from 1982 to 2006 to determine what was making the Sahel greener. This was done by examining a series of normalized difference vegetation index (NDVI) satellite images, which are a good indicator of photosynthetic activity in a given area. The changes in the index were analysed in line with rainfall and land use changes, the two main factors that determine vegetation dynamics in the Sudano-Sahelian zone.

Over the period 1982-2006, there was no change in annual rainfall in the catchment area. However, cultivated areas increased from 13% to 23% between 1985 and 2000. Analysis of these results failed to find any clear links between the greening of the catchment area and land use changes.

Expanded cropping only explained the trend in northern Bani, in the Sahelian zone, where crops had a higher vegetation index than the natural vegetation. The greening in the catchment area was thus primarily due to natural vegetation dynamics. These dynamics were in fact dependent on rainfall distribution over the last 25 years, rather than on rainfall trends.

Indeed, although there was a rainfall deficit from 2000 to 2006, rainfall increased between 1982 and 1999. Perennial plants were able to make use of that increase to survive during the subsequent dry period.

This study shows the limitations of trend analyses in remote sensing and climatology based on linear relations, which are too simplistic to accurately reproduce the environmental and geographical phenomena at work. ■

**Partners >**  
Centre national  
de la recherche  
scientifique (CNRS),  
Institut de  
recherche pour  
le développement  
(IRD)

CONTACT > Agnes Bégué, Elodie Vintrou,  
Montpellier, Spatial Information and  
Analysis for Territories and Ecosystems  
(UMR TETIS)

Bégué A. et al., 2011. Can a 25-year trend in vegetation dynamics (NOAA-AVHRR NDVI) be interpreted in terms of land use change? A case study of the Bani catchment in Mali. *Global Environmental Change*. Doi: 10.1016/j.gloenvcha. 2011. 02.002.

The greening of the Sahel appears to be primarily linked to natural vegetation dynamics © E. Vintrou/CIRAD





Sweet potato, a crop that is susceptible to chlordecone contamination  
© F. Clostre/CIRAD

## Managing chlordecone pollution in the French West Indies

*Chlordecone is a persistent organochlorine insecticide that is potentially carcinogenic. Used from 1971 to 1993 in the French West Indies to control the banana black weevil, it resulted in the pollution of soils, crops, water and ecosystems. CIRAD and INRA set up a research programme in 2006 to manage this pollution and study its mechanisms. Its initial findings help to better understand how certain fruits and vegetables are contaminated and to propose simple management tools for West Indian farmers in order to ensure the safety of their products.*

Almost 20 years after its use was banned in the French West Indies, chlordecone is still present in the soils and contaminates certain crops grown there. A vast research project was launched in 2006, alongside the national plan of action, to find a means of eliminating this pesticide and ensuring the health safety of agricultural products. Specifically, CIRAD is responsible for studying the transfer of the molecule from

soil to the plant, which makes it possible to anticipate the risk of contamination of marketed products.

### Passive accumulation in plants

The surveys and experiments conducted in the field provide a general outline of transfer from the soil to the different plant organs.

**Partners >**  
Institut national de la recherche agronomique (INRA), Institut de recherche pour le développement (IRD), University of the French West Indies and Guiana.  
The Chlordexco project is cofinanced by the Agence nationale de la recherche (ANR)

They show that crop contamination depends on the capacity of roots to extract and transfer the molecule to the plant tissues. The levels of chlordecone in plant tissues are always far lower than those measured in the soil. No active accumulation, giving hope of phytoremediation, has been identified. After uptake by the roots, the molecule is transferred by passive means, primarily through the raw sap flow. Next, the accumulation of the molecule in



the different organs depends on the position of the organ in the sap flow system, on its size and on the intervention of plant tissues acting as filters or receptors before the filling process of the eaten part of vegetables or fruits. These trials were conducted on soil types that varied greatly in terms of their affinity for chlordecone: andosols, which are often highly polluted as they absorb considerable amounts of the molecule, and nitisols, which are far less polluted since they fix the molecule less, but release the pollutant more into the environment, thereby contaminating water and plants.

## Management tools to minimise product contamination

To comply with regulations on the maximum residue limits for food products, the maximum transfer curves measured between the soil and plants were used. They made it possible to determine the soil contamination limits beyond which certain crops were not recommended, in other words, over this limit the risk of contamination of the harvested organ is not nil. This risk of contamination can then be anticipated as soon as the field is prepared for planting, and crop species can be chosen according to their susceptibility and to the chlordecone content of the soil.

Three types of crops can be identified: susceptible crops, with high transfer and contamination levels (roots and tubers); intermediate crops, whose contamination levels remain close to the maximum residue limit (lettuces, Cucurbitaceae, sugarcane); and crops with very low contamination levels (fruit trees, pineapples, bananas, Solanaceae, cabbages, beans, etc.), which can be grown whatever the level of soil pollution. This tool, once validated by the State departments and translated into measures, will be used within the framework of



Dasheen producer, Martinique  
© M. Lesueur-Jannoyer/CIRAD

recommendations for the restructuring of farms.

These studies also led to a series of recommendations for consumers. First, it is essential to carefully wash and brush vegetables before preparing them, in order to avoid ingesting any soil. If there is any doubt as to the origin of vegetables, peeling a thick layer will considerably reduce the risks for yam, squash, watermelon and melon. But there is no need to boil vegetables, which would only reduce their nutritional value without any effect on the chlordecone. ■

CONTACT > Magalie Lesueur-Jannoyer,  
Agroecological Functioning and  
Performances of Horticultural Cropping  
Systems

Lesueur-Jannoyer M. et al., 2010. Evaluation de la contamination par la chlordécone et de son transfert dans les cultures sur différents sols des Antilles. Ministère de l'Outre-mer, Pram, CIRAD, 29 p.

[www.pram-martinique.org](http://www.pram-martinique.org)

## Decontamination, a possible solution?

In May, around 30 experts met in the French West Indies for an international workshop organised by CIRAD and INRA to remediate the pollution and to set new guidelines for research. Given that the spontaneous biodegradation of chlordecone is limited in agricultural soils, the aim was to explore new options for the microbial degradation of the molecule, especially by forcing the adaptation of micro-organisms and by identifying microbial associations able to perform a full degradation. Phytoremediation, a decontamination process based on the use of plants to degrade toxic substances, may also be a solution, but research is in its early stages and initial results do not indicate that effective phytoextraction is possible. Other solutions are being considered, such as the use of service crops and organic amendments with a high affinity for chlordecone to reduce its transfer to the environment and crops. For water treatment, the use of activated carbon has proved efficient, but poses the problem of its reprocessing. Once again, bacterial degradation in reducing conditions offers some interesting prospects. Faced with an unusually widespread and lasting form of pollution, it is also important to test modes of management and monitoring at the watershed level, a relevant scale for future scientific projects and long-term measurements. This innovative approach will provide a generic model for similar problems in other parts of the world.

# Indicators

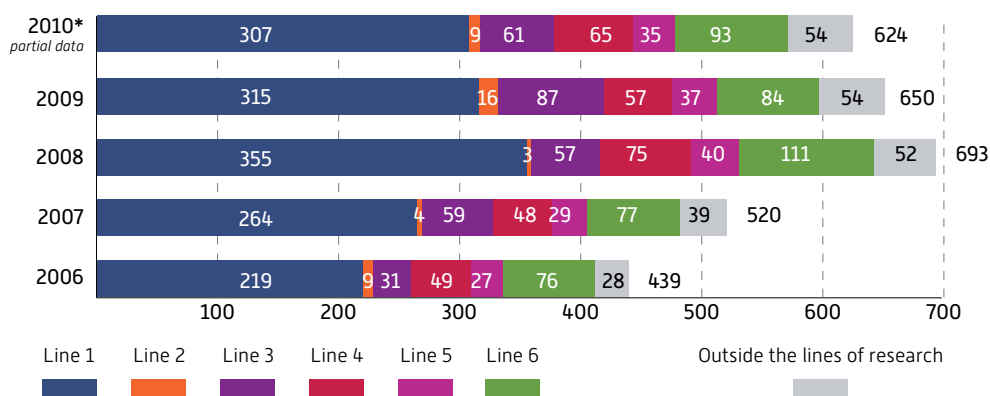
In line with its commitments to its supervising ministries, CIRAD is continuing to implement its State–CIRAD Agreement on Objectives, which sets out its strategy for the 2008–2011 period. The Agreement includes four main priorities that will guide CIRAD in the coming years: ensuring shared science in response to the challenges faced by developing countries; producing varied, quality scientific output; opening up national agricultural research operations to Europe and the rest of the world; and tailoring the establishment’s structure and resources to current issues.

## Ensuring shared science in response to the challenges faced by developing countries

“Ensuring shared science in response to the challenges faced by developing countries” aims to transform the conditions of scientific partnerships so as to focus more specifically on relevant research issues, thus enhancing progress in developing countries. The mobilization of research teams around the six priority lines of research outlined in CIRAD’s Strategic Vision 2008–2012, in addition to initiatives undertaken to strengthen expertise in developing countries, is pivotal to this challenge.

### Share of CIRAD publications according to priority line of research (Agritrop)

[Articles published in peer-review journals, with or without ISI impact factor]\*



\*Publication indicators reflect the status of the institutional database, Agritrop, as of 15 March 2011 at the end of the day. Data and indicators for 2010 are partial

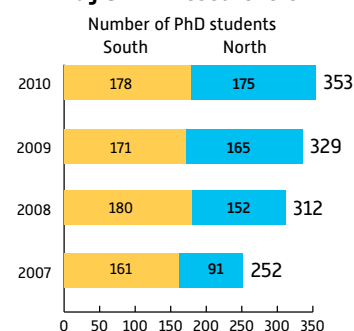
CIRAD has opted to favour balanced, sustainable partnerships with its scientific partners in developing countries. This is borne out by the share of co-publications with players in developing countries in relation to co-publications as a whole (almost 50% in 2009), and the steady growth in the proportion of CIRAD co-publications with organizations in developing countries averaged over the 3-year period between 2007 and 2010 (from 43.26% to 47.03%). The number of PhD students from developing countries supervised by CIRAD researchers increased in 2010 following the decline in 2009.

### Co-publications with players from developing countries<sup>1</sup>

Values for 2010	2005	2006	2007	2008	2009	2010 <sup>2</sup>
Researchers from developing countries	182	188	233	308	323	294
Total publications analysed	435	439	520	693	650	624
Share (%) of co-publications with researchers from developing countries	41.84	42.82	44.81	44.44	49.69	47.12
Share (%) of co-publications with researchers from developing countries averaged over 3 years	–	–	43.26	44.13	46.38	47.03

1 A country is classed as developing if it is on the OECD list of countries benefiting from public development aid. 2 Partial data,

### Supervision of PhD students by CIRAD researchers



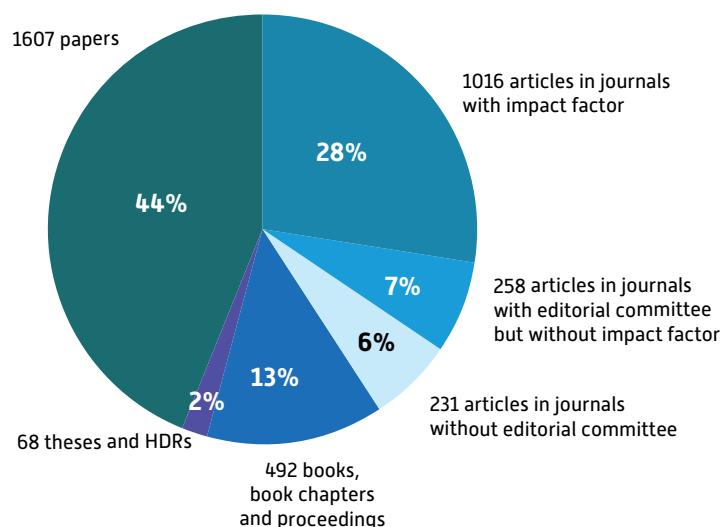


# Varied, quality scientific output

To bring science for development up to the very highest scientific level on a global scale, while ensuring that it remains anchored in the issues, areas and partnerships specific to developing countries, CIRAD is boosting the quality of its scientific publications and the competitiveness of its teams, while ensuring the diversity of its outputs aimed at various audiences.

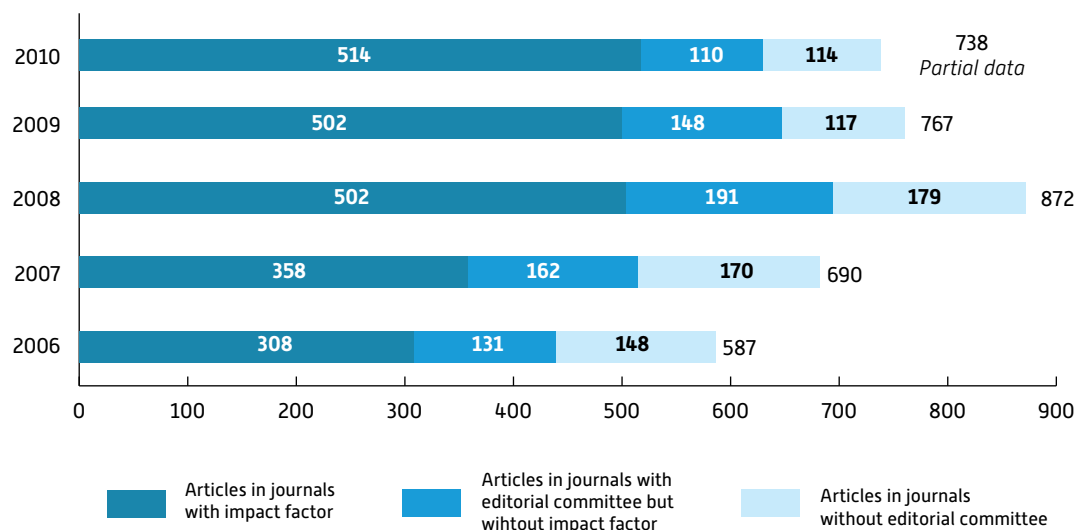
The quality of CIRAD's scientific output has increased considerably, notably with the marked growth in the number of articles published between 2006 and 2010, especially in ISI impact-factor journals, while the level of qualification of CIRAD researchers has been steadily increasing (number of research directors). The success rate as regards ANR calls for proposals declined in 2010 due to team saturation. The involvement of CIRAD staff in training in and through research has levelled off (number of teaching hours in Master's courses in developing countries, and number of 'teacher-consultant' titles). In 2010, technology transfer and development outputs returned to their usual values following an exceptional year in 2009.

**Distribution of publications in 2009 et 2010 (Total: 3672)**



2010 data are partial (as of 15/03/2011)

**Changes in the number of journal articles published since 2006 (total: 3654)**



### CIRAD participation in ANR competitive calls for proposals

	2007	2008	2009	2010
Number of projects submitted	75	72	49	65
Number of projects funded	23	19	14	12
Success rate [%]	31	26	29	18

### CIRAD participation in teaching and training engineering for Master's and PhD courses in developing countries

	2007	2008	2009	2010
Number of hours' practical work equivalent	3978	4249	4439	4368

### Research training of senior CIRAD scientific staff

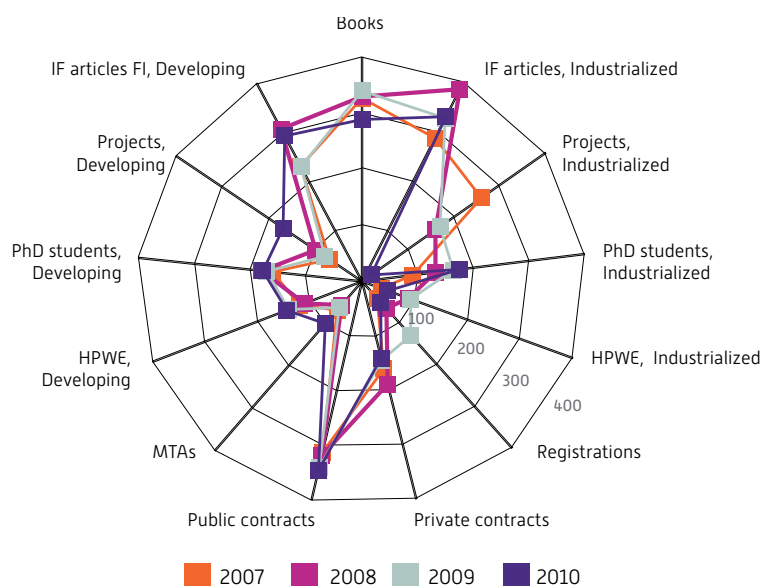
	2007	2008	2009	2010
Number of research directors	82	90	99	102
Number of teacher-consultants	nc	36	52	53

### Technology transfer and development: patents, plant variety protection certificates and softwares

	2007	2008	2009	2010
Numbers <i>[including, numbers of patents]</i>	8 [2]	13 [0]	26 [4]	10 [5]

## Assessing the diversity of CIRAD scientific outputs

The range of outputs presented above is proof of the variety of missions and operations accomplished by CIRAD. In 2010, CIRAD developed a pilot indicator of output diversity, in the form of a star diagram, for the years 2007–2009, at the request of its Science Council. In 2011, this indicator was recalculated for 2007–2010. It is the result of a selection of outputs, which are weighted: firstly publications (articles published in peer-reviewed journals with and without impact factor, ie IF articles), PhD students supervised [PhD students], hours of Master's and PhD teaching [HPWE], and participation in ANR and EU FP7 competitive projects [projects] with, on the left, activities directly associated with researchers from developing countries, and on the right, those concerning researchers from industrialized countries. There are also outputs that cannot be split North/South: production of books, registration of patents, PVPCs and software, Material Transfer Agreement (MTA) declarations, and contracts funded by the public and private sectors. 2010 was marked by an improvement in the weight placed on outputs oriented towards developing countries (projects, teaching, supervision of PhD students).



## A research agenda open to Europe and the rest of the world

CIRAD has been working on several levels since 2008: in French regions, in units devoted to training and research (PRES, in Languedoc-Roussillon; in French overseas regions; and on the sustainable development campus at Nogent); in France, within its alliance with INRA, expanded to include the Agreenium national consortium since 2009, with other research organizations under Programme 187, particularly IRD, and more recently with research alliances (ALLENVI, ENCRE); in Europe, through strengthened partnerships; and finally globally, through a renewal of partnerships in developing countries around priority research platforms, and through the strengthening of links with the Consultative Group on International Agricultural Research [CGIAR]. The increase in co-publications illustrates the global priority, especially with respect to developing countries. However, staff assignments and missions in developing countries declined slightly in 2010, but not in Sub-Saharan Africa and in French overseas regions, with priority research platforms gradually taking centre stage since 2009.



## Co-publications with French, EU or global players

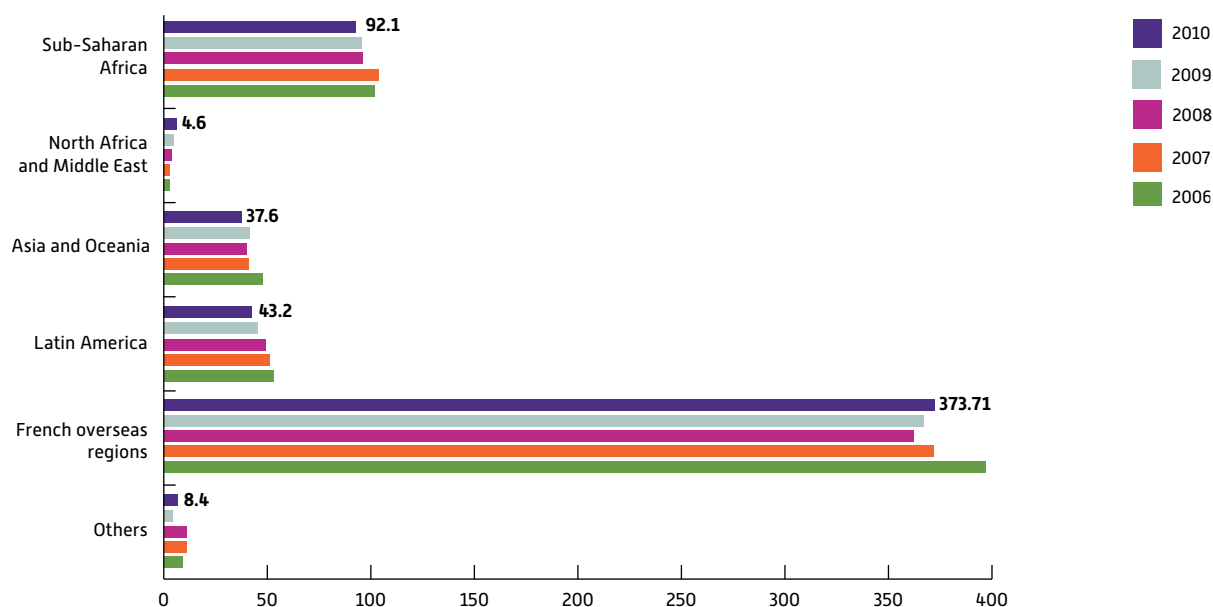
To eliminate between-year fluctuations and get a clearer picture of the trends, it is common to recover certain publication indicators while smoothing all of the data or parts over 3 years. The values are calculated by full counting; these values are not additive because, for instance, a given article may be co-signed by a French researcher and a global researcher.

Articles in peer-review journals, with or without ISI impact factor in parts (%) of the annual mean smoothed over 3 years	2007	2008	2009	2010 <i>Partial data</i>
French researchers (including INRA)	45.19	46.31	46.16	44.59
French researchers (EU excluding France)	10.76	12.89	13.10	14.49
Global researchers (excluding EU27)	49.21	50.91	53.46	54.45
Developing country researchers	43.26	44.13	46.38	47.03
P187 researchers	26.11	28.09	28.02	25.78
INRA	17.00	19.37	18.95	17.84

## CIRAD co-publications with each organization involved in LOLF Programme 187

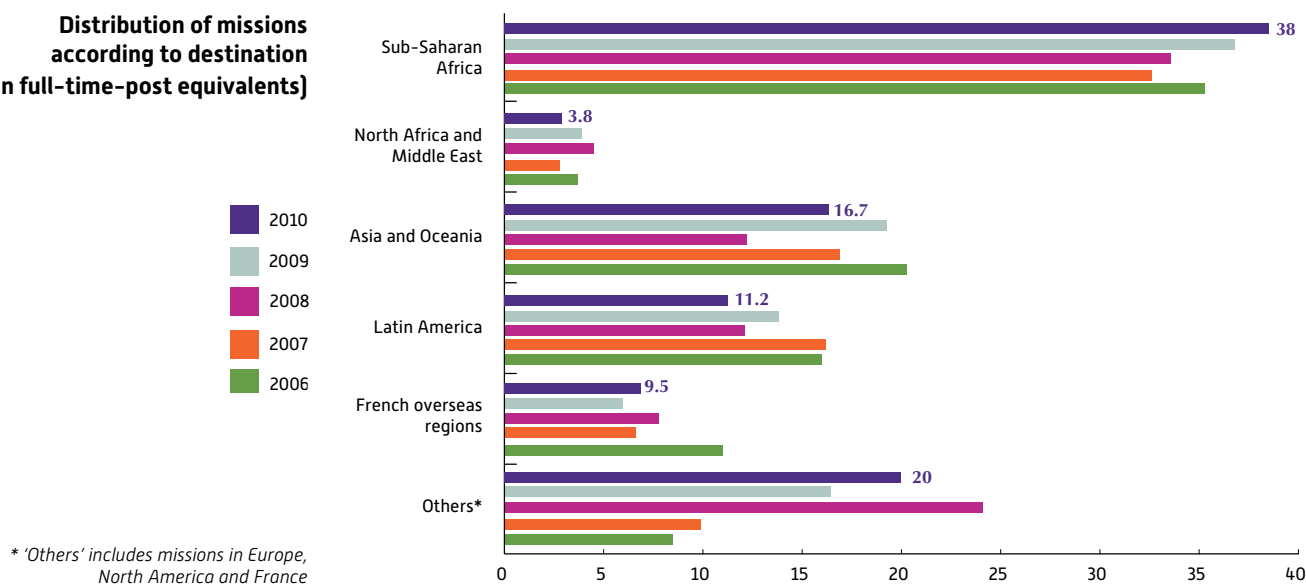
Articles in peer-review journals, with or without ISI impact factor in parts (%) of the annual mean smoothed over 3 years	2007	2008	2009	2010 <i>Partial data</i>
CEMAGREF	0.86	1.45	2.06	2.18
IFREMER	0.14	0.12	0.18	0.06
INRA	17.00	19.37	18.95	17.84
IRD	9.76	9.26	9.29	7.88
BRGM	0	0	0	0

## Distribution of assignments to developing countries (in full-time-post equivalents)



\* 'Others' includes missions in Europe, North America and France

**Distribution of missions  
according to destination  
(in full-time-post equivalents)**



**Number of senior scientific staff assigned to priority research platforms/number of senior scientific staff on overseas assignments  
(full-time-post equivalents)**

**2008:** 111 senior scientific staff assigned to 18 priority research platforms out of 291 senior scientific staff on overseas assignments

**2009:** 137 senior scientific staff assigned to 23 priority research platforms (20 global PRPs + 3 PRPs in DOM) out of 267 senior scientific staff on overseas assignments

**2010:** 149 senior scientific staff assigned to 27 priority research platforms\* (20 global PRPs + 7 PRPs in DOM) out of 273 senior scientific staff on overseas assignments  
[\* 5 more PRP including 4 DOM; 1 fewer PRP]

Region	National priority research platforms (PRPs)	Regional priority research platforms	DOM*	PRPs in DOM
<b>Africa</b>				
	URP PPZS, Senegal	CIRDES, West Africa	Réunion	3P, Line 1
	RP-PCP, Zimbabwe, Lines 1, 4, 6	ZIE, West Africa, Lines 1, 6		Réagir, Line 6
	CR2PI, Congo, Lines 1, 6	PRASAC-GIFSEC, Central Africa, Lines 1, 6		Kappa, Line 3
	PCP Grand Sud, Cameroon, Lines 1, 3	CARBAP, Central Africa, Lines 1, 3		
	URP SCRID, Madagascar, Line 1	DPFAC Congo Basin Forests, Central Africa, Lines 5, 6		
	URP Forêt Biodiversité, Madagascar, Lines 2, 6			
<b>Asia</b>				
	PCP – MALICA, Vietnam, Line 1	RCP CANSEA, (RACASE), Southeast Asia, Line 1		
	PCP – PRISE, Vietnam, Lines 1, 4			
	PCP – HRPP, Thailand, Line 1			
	GREASE Animal health and emerging diseases, Line 4			
<b>Latin America</b>				
	AFS-PC Agroforestry Systems with Perennial Crops, Central America, Lines 1, 2, 5, 6		West Indies French Guiana	Forests
	CIBA, Brazil, Line 1			Agroecology and multispecies cropping systems
	Amazonia		Biodiversity and genetics	
			Animal health and emerging diseases, Line 4	
<b>Mediterranean</b>				
	SIRMA RCP, North Africa, Lines 1, 3, 5, 6			

\*DOM: French overseas regions

**CIRAD EU research and development (FP) projects between 2007 and 2010**

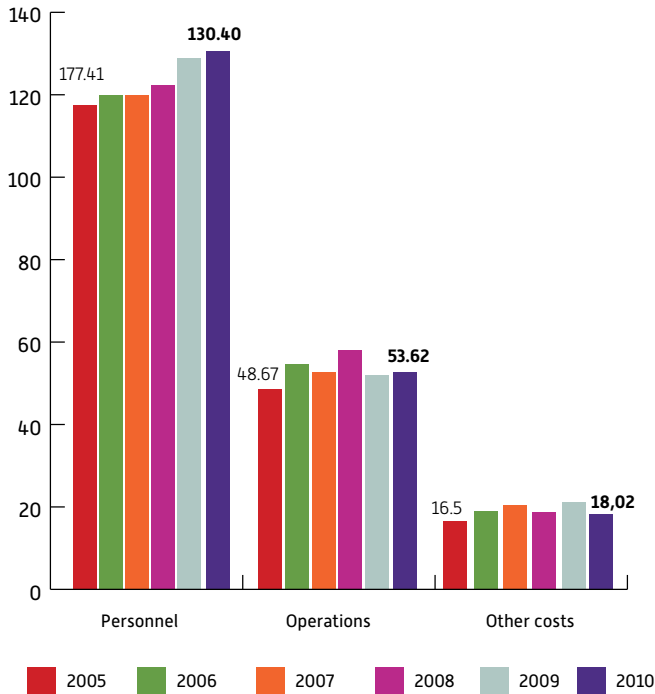
	2007	2008	2009	2010
Number of submitted projects	36	23	23	18
Number of funded projects	10	7	11	7
Success rate [%]	28	30	48	39
Number of projects coordinated by CIRAD	0	4	3	2



# An organization and resources tailored to new challenges

In addition to simplifying and modernizing its management methods, guided by its scientific objectives, CIRAD has also set out to optimize its human and financial resources through stabilization.

**Operating costs, excluding internal sub-contracting, for 2005-2010, in million euros**



CIRAD is striving to maintain its contractual resources by stabilizing its operational expenditures and human resources, while the increase in grant-funded PhD students offset the decline in staff with long-term contracts (CDIs) in 2010. CIRAD policies geared towards boosting quality through simplification and efficiency enhancement are gradually having an impact on an increasing number of the establishment's scientific and administrative agents.

**Total number of CIRAD staff members (full-time-post equivalents)**

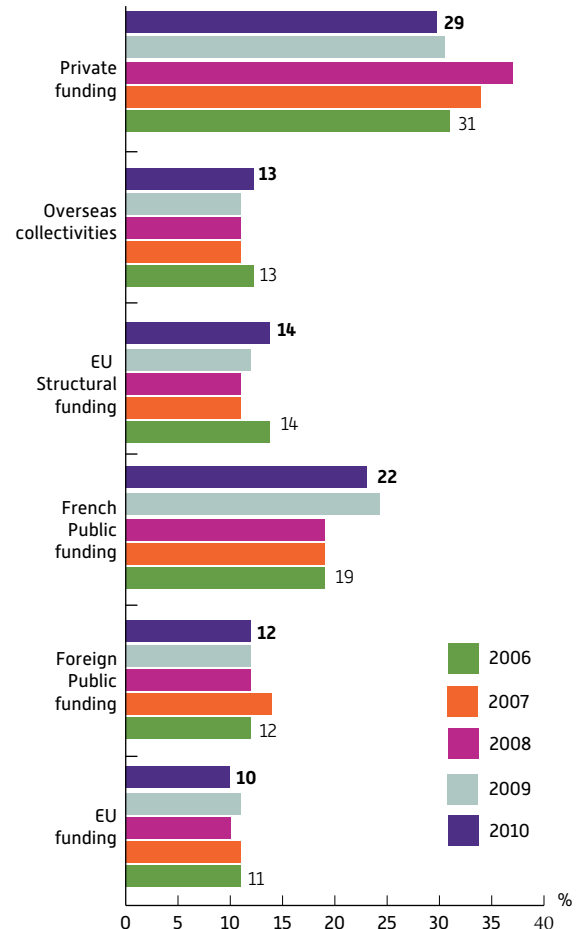
FTPes at CIRAD	2007	2008	2009	2010
No. of 'classified, paid' staff members on CDIs or CDDs*	1770	1755	1764	1752
No. of grant-funded PhD students	24	48	71	83

\* CDI: long-term contract, CDD: fixed-term contract

**Number of units (in terms of staff numbers) applying a quality approach**

	2007	2008	2009	2010
Number of units (in terms of staff numbers) applying a quality approach (levels 1/2 to 5)	375	444	853	929

**Self-generated resources\*: volume and annual breakdown as a percentage (excluding co-contracting)**



\* The 2008-2009 variation in the share of self-generated resources of private origin can be attributed to the transfer of assets to CIRAD's PalmElit joint venture.

**Annual breakdown of 'classified, paid' jobs per category, as a percentage (including grant-funded PhD students with CIRAD contracts)**

	2007	2008	2009	2010
Senior staff members	59	58.8	59.2	59.6
Grant-funded PhD students	1.3	2.7	3.9	4.6
White-collar staff members	31.6	31.8	31.4	31.5
Ancillary staff members	8	6.7	5.5	4.4

# Organization in May 2011

## Board of Trustees

Chair  
Gérard Matheron

Bernard Commère, representing the Minister of Higher Education and Research

Philippe Thiebaud, representing the Minister of Foreign and European Affairs

Grégory Cazalet, representing the Minister for the Budget, Public Accounts and the Civil Service

Marion Zalay, representing the Minister of Agriculture, Food, Fisheries, Rural Affairs and Spatial Planning

Arnaud Martrenchar, representing the Minister of the Interior, Overseas Territories and Territorial Communities

Gilles Bœuf, Chair of the Science Council of the Muséum national d'histoire naturelle

Zoubida Charrouf, Professor, Faculté des sciences de Rabat

Marion Guillou, President, Institut national de la recherche agronomique

Michel Laurent, President-Director General, Institut de recherche pour le développement

Paul Luu, Director, ODEADOM

Laurence Tubiana, Director, Institut du développement durable et des relations internationales

François Affholder, elected staff representative

Martine Antona, elected staff representative

François Bousquet, elected staff representative

Laurent Maggia, elected staff representative

Jean-Louis Noyer, elected staff representative

Philippe Vernier, elected staff representative

Secretary, Jean-Louis Muron  
Writer, Pierre-Luc Pugliese

## Science Council

Chair  
Bertrand Hervieu, Conseil général de l'agriculture, de l'alimentation et des espaces ruraux

Akissa Bahri, African Development Bank, Tunisia

Bernard Chevassus-au-Louis, Conseil national de l'agriculture, France

Marie-Christine Cormier-Salem, Institut de recherche pour le développement, France

Michel Dron, University of Paris XI, France

Bernadette Kamgnia Dia, University of Yaoundé II, Cameroon

Olivier Le Gall, Institut national de la recherche agronomique, France

Claudine Schmidt-Lainé, Centre national de la recherche scientifique, France

Lamine Seiny Boukar, Pôle régional de recherche appliquée au développement des savanes d'Afrique centrale, Chad

Marco Wopereis, Africa Rice Center, Bénin

Marie-Line Caruana, elected staff representative

Régis Goebel, elected staff representative

Raphaël Morillon, elected staff representative

Vincent Ribier, elected staff representative

Guy Trébuil, elected staff representative

Secretary, Jean-Louis Sarah

## INRA-CIRAD Joint Consultative Committee on Ethics in Agricultural Research

Chair  
Louis Schweitzer, Haute autorité de lutte contre les discriminations et pour l'égalité

Fifi Benaboud, North-South Centre, Council of Europe

Gilles Bœuf, Chair of the Science Council of the Muséum national d'histoire naturelle

Marcel Bursztyn, Socioeconomist, University Professor

Claude Chéreau, Historian, Honorary Inspector General of Agriculture

Soraya Duboc, Agrifood Scientist, Nestlé France

Patrick Du Jardin, Agronomist, Lecturer at and Dean of the University of Gembloux

Catherine Larrère, Lecturer in Applied Ethics at the University of Paris I - Panthéon-Sorbonne

Jeanne-Marie Parly, Associate Professor of Economic Science

Gérard Pascal, Nutritionist, Honorary Research Director

Lazare Marcelin Poamé, Dean of the Arts and Human Sciences Training and Research Unit at the University of Bouaké, Chair of the National Consultative Committee on Bioethics, Côte d'Ivoire

Gérard Toulouse, Associate Professor of Science, Research Director, Theoretical Physics Laboratory, Ecole normale supérieure

Dominique Vermersch, Agronomist, Lecturer in Public Economics and Ethics, Agrocampus Rennes

Heinz Wismann, Philosopher and Philologist, Lecturer at the Ecole des hautes études en sciences sociales

## Office of the Director General

Gérard Matheron, President

Michel Griffon, adviser

Etienne Hainzelin, adviser

Jean-Louis Muron, adviser

Alain Weil, adviser

Jacques Pagès, Director General in charge of Resources and Organization

André Nau, Regional Director, Ile-de-France

Michel Salas, Regional Director, Languedoc-Roussillon

Gilles Mandret, Regional Director, Réunion-Mayotte

Philippe Godon, Regional Director, West Indies-French Guiana

Anne Hébert, Coordinator, Communication

Anne-Yvonne Le Dain, Coordinator, Evaluation

Léandre Mas, Coordinator, Quality

Joël Sor, Coordinator, Information Systems

## Office of the Director General in charge of Research and Strategy

Patrick Caron, Director General in charge of Research and Strategy

Marcel de Raïssac, Associate Director

André de Courville, Coordinator, Latin America and Caribbean

Rolland Guis, Coordinator, Africa and Indian Ocean

Catherine Marquié, Coordinator, European Community

Marie-Claude Deboin, Coordinator, Scientific and Technical Information

Claudie Dreuil, Coordinator, Incentive Operations

Rémy Hugon, Coordinator, Technology Transfer and Development

Mireille Mourzelas, Coordinator, Higher Education and Training

Hubert Omont, Coordinator, Tropical Supply Chains

Jean-Louis Sarah, Coordinator, Strategic Operations

## Office of the Director of Finance and Administration

Patrick Herbin, Interim Director of Finance and Administration

Marc Gélis, Manager, Accounts and Finance

Vincent Fabre-Rousseau, Manager, Human Resources

Didier Servat, Technical Manager, Installations and Maintenance

André Nau, Management Supervision Officer

Aleth de Sartiges, Safety Officer

Yann Combot, Archives Officer



## Research Departments and Units

### Biological Systems Department

Daniel Barthélémy, Director  
Dominique Berry, Deputy Director  
Xavier Mourichon, Associate Director

#### *Research Units\**

Biology and Genetics of Plant-Pathogen Interactions (UMR BGPI: INRA, Montpellier SupAgro), Philippe Rott  
Botany and Computational Plant Architecture (UMR AMAP: CNRS, University of Montpellier 2, INRA, IRD), Pierre Couteron (IRD)  
Centre for Biology and Management of Populations (UMR CBGP: INRA, IRD, Montpellier SupAgro), Flavie Vanlerberghe (INRA)  
Centre of Evolutionary and Functional Ecology (UMR CEFE: CNRS, Universities of Montpellier 1, 2 and 3, Montpellier SupAgro, EPHE), Philippe Jarne (CNRS)  
Crop Diversity, Adaptation and Development (UMR DIADE: IRD, Montpellier SupAgro, INRA, University of Montpellier 2), Serge Hamon (IRD)  
Emerging and Exotic Animal Disease Control (UMR CMAEE: INRA), Dominique Martinez  
Genetic Improvement and Adaptation of Mediterranean and Tropical Plants (UMR AGAP: INRA, Montpellier SupAgro), Jean Christophe Glaszmann  
Host-Vector-Parasite Interactions in Infections by Trypanosomatidae (UMR InterTryp: IRD), Gérard Cuny (IRD)  
Laboratory of Tropical and Mediterranean Symbioses (UMR LSTM: University of Montpellier 2, INRA, IRD, Montpellier SupAgro), Michel Lebrun (University of Montpellier 2)  
Pests and Diseases: Risk Analysis and Control (UPR), Christian Cilas  
Plant Communities and Biological Invaders in Tropical Environments (UMR PVBMT: University of Réunion), Bernard Reynaud  
Plant Resistance to Parasites (UMR RPB: IRD, University of Montpellier 2), Michel Nicole (IRD)

### Performance of Tropical Production and Processing Systems Department

Robert Habib, Director  
François Côte, Deputy Director  
André Rouzière, Associate Director

#### *Research Units\**

Agroecological Functioning and Performances of Horticultural Cropping Systems (UPR), Eric Malézieux  
Agropolymer Engineering and Emerging Technologies (UMR IATE: University of Montpellier 2, INRA, Montpellier SupAgro), Hugo de Vries (INRA)  
Annual Cropping Systems (UPR), Florent Maraux  
Banana, Plantain and Pineapple Cropping Systems (UPR), Jean-Michel Risède  
Biomass and Energy (UPR), Sylvie Mouras  
Conservation Agriculture and Engineering (UPR), Jean-Claude Legoupil  
Functional Ecology and Biochemistry of Soils and Agrosystems (UMR Eco&Sols: IRD, Montpellier SupAgro, INRA), Jean-Luc Chotte (IRD)  
Integrated and Ecological Intensification for Sustainable Fish Farming (UMR INTREPID: IFREMER), Jean-François Baroiller  
Integrated Food Quality System (UMR QUALISUD: Universities of Montpellier 1 and 2, Montpellier SupAgro), Max Reynes  
Performance or Tree Crop-Based Systems (UPR), Eric Gohet  
Production and Processing of Tropical Woods (UPR), Jean Gérard  
Recycling and Risks (UPR), Hervé Saint Macary  
Tropical and Mediterranean Cropping System Functioning and Management (UMR SYSTEM: INRA, Montpellier SupAgro), Christian Gary (INRA)  
Tropical and Mediterranean Cropping System Functioning and Management (UMR Water, Soil and Plant Analysis (US), Daniel Babre

### Environment and Societies Department

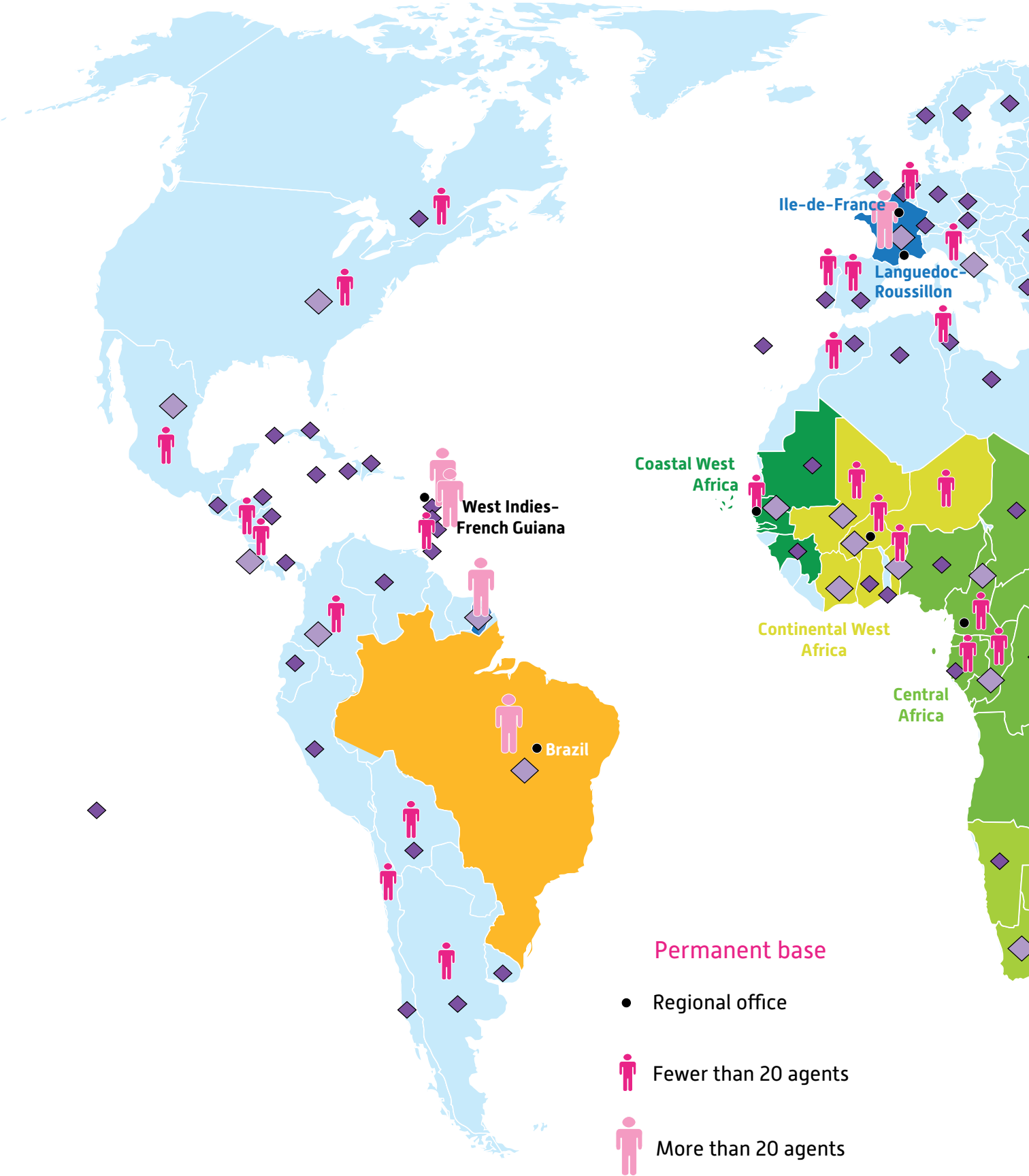
Pierre Fabre, Director  
Hubert Devautour, Deputy Director  
Pascal Bonnet, Associate Director

#### *Research Units\**

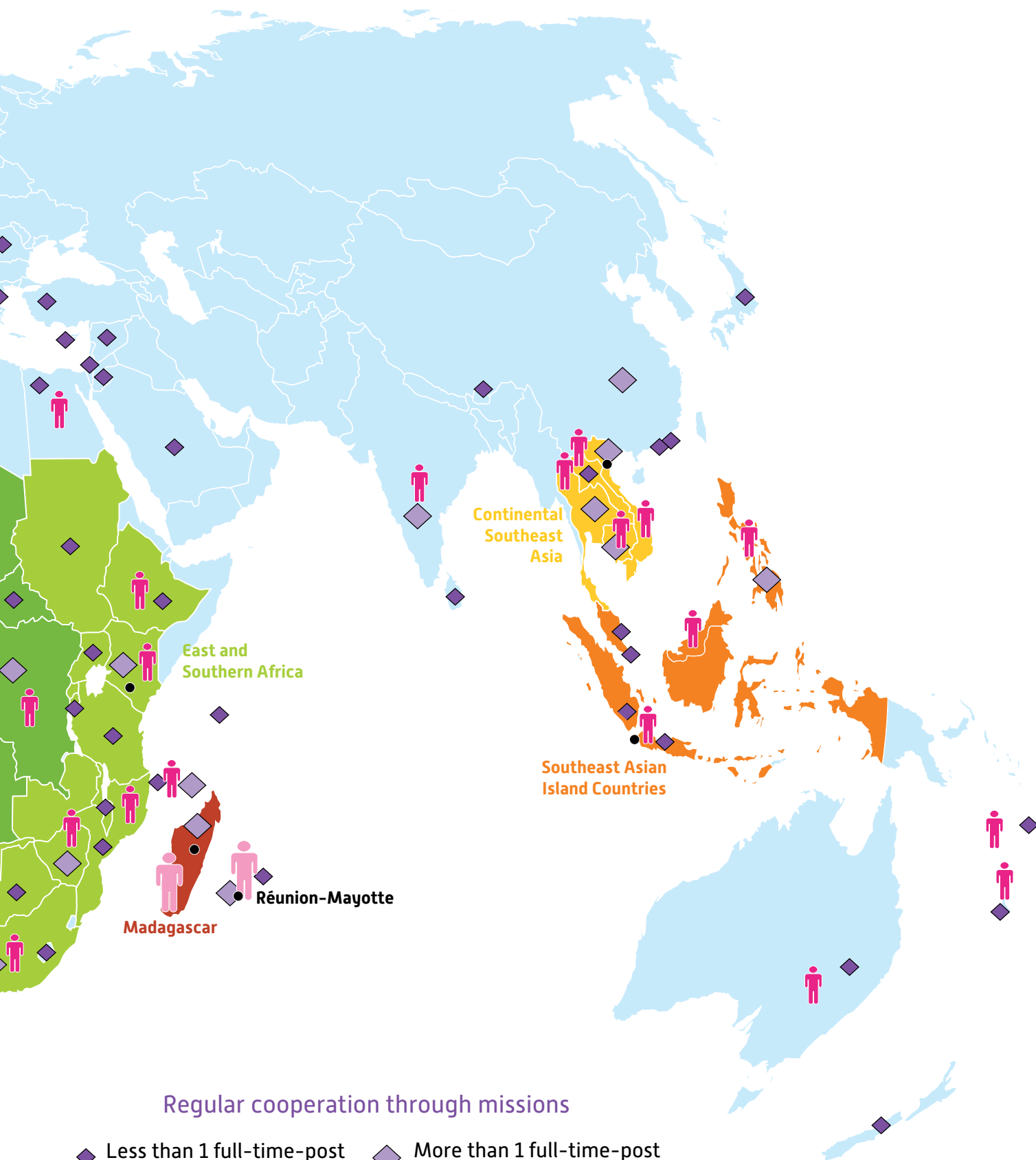
Actors, Resources and Territories in Development (UMR Art-Dev: University of Montpellier 3, CNRS), Geneviève Cortes (University of Montpellier 3)  
Animal and Integrated Risk Management (UPR), François Roger  
Centre for International Research on Environment and Development (UMR CIREN: CNRS, EHESS, AgroParisTech, École des Ponts ParisTech), Jean-Charles Hourcade (CNRS-EHESS)  
Ecology of the Forests of French Guiana (UMR ECOFOG: AgroParisTech, INRA, CNRS, University of the West Indies and French Guiana), Eric Marcon (AgroParisTech)  
Innovation and Development in Agriculture and the Agrifoods Sector (UMR Innovation: INRA, Montpellier SupAgro), Christophe Soulard (INRA)  
Management of Renewable Resources and Environment (UPR), Martine Antona  
Markets, Organizations, Institutions and Operators' Strategies (UMR MOISA: CIHEAM-IAMM, INRA, Montpellier SupAgro), Etienne Montaigne (CIHEAM-IAMM)  
Mediterranean and Tropical Livestock Systems (UMR SELMET: Montpellier SupAgro, INRA), Philippe Lecomte  
Spatial Information and Analysis for Territories and Ecosystems (UMR TETIS: CEMAGREF, AgroParisTech), Jean-Philippe Tonneau  
Tropical Forest Goods and Ecosystem Services: Facing Global Change (UPR), Alain Billand  
Water Resource Management, Actors and Uses (UMR G-EAU: CEMAGREF, AgroParisTech, IAMM, IRD, Montpellier SupAgro), Patrice Garin (CEMAGREF)

\* UMR: Joint Research Unit  
UPR: Internal Research Unit  
US: Service Unit

# CIRAD worldwide







# Facilities worldwide

## France

### *Ile-de-France*

André Nau,  
Regional Director  
42, rue Scheffer  
75116 Paris  
Tel.: +33 1 53 70 20 21  
andre.nau@cirad.fr

### *Languedoc-Roussillon*

Michel Salas,  
Regional Director  
Avenue Agropolis  
34398 Montpellier Cedex 5  
Tel.: +33 4 67 61 58 01  
jacques.pages@cirad.fr

### *West Indies-French Guiana*

Philippe Godon,  
Regional Director  
Station de Neufchâteau  
Sainte-Marie  
97130 Capesterre-Belle-Eau,  
Guadeloupe  
Tel. : +590 5 90 86 17 90 /  
+590 6 94 45 10 22  
philippe.godon@cirad.fr

Jean-Marc Deboin,  
Correspondent  
BP 701, avenue de France  
97387 Kourou Cedex, Guyane  
Tél. : +594 5 94 32 73 52  
jean-marc.deboin@cirad.fr

Christian Chabrier,  
Correspondent  
BP 214  
97285 Le Lamentin Cedex 2  
Martinique  
Tel.: +596 5 96 42 30 44  
christian.chabrier@cirad.fr

### *Réunion-Mayotte*

Gilles Mandret,  
Regional Director  
Station de La Bretagne, BP 20  
97408 Saint-Denis Messagerie  
Cedex 9  
Réunion  
Tel. : +262 2 62 52 81 00 /  
+262 6 92 76 30 69  
gilles.mandret@cirad.fr

## Africa

### *Central Africa*

Jean-Luc Battini,  
Regional Director  
BP 2572  
Yaoundé, Cameroon  
Tel. : +237 22 21 25 41  
jean-luc.battini@cirad.fr

Philippe Vigneron,  
Correspondent in the Congo  
Pointe Noire: Consulate  
13, rue Louveau  
92438 Chatillon Cedex  
Tel. : +242 53 56 35 65  
philippe.vigneron@cirad.fr

Eric Forni,  
Correspondent in Gabon  
BP 4035  
Libreville, Gabon  
Tel.: +241 07 49 28 21  
eric.forni@cirad.fr

### *East and Southern Africa*

Jacques Lançon,  
Regional Director  
C/o ICRAF, United Nations Avenue  
Gigiri, PO Box 30677  
00100 Nairobi, Kenya  
Tel.: +254 20 722 46 53  
jacques.lancon@cirad.fr

Emmanuel Torquebiau,  
Correspondent in South Africa  
Centre for Environmental Studies  
[CFES]  
University of Pretoria  
0002 Pretoria, South Africa  
Tel.: +27 12 420 43 18  
emmanuel.torquebiau@cirad.fr

Michel de Garine-Wichatitski,  
Correspondent in Zimbabwe  
CIRAD  
PO Box 1378  
Harare, Zimbabwe  
Tel.: +263 4 33 24 87  
degarine@cirad.fr

### *Continental West Africa*

Michel Partiot,  
Regional Director  
01 BP 596  
Ouagadougou 01, Burkina Faso  
Tel.: +226 50 30 70 70  
michel.partiot@cirad.fr

### *Coastal West Africa*

Denis Depommier,  
Regional Director  
37, avenue Jean XXIII  
BP 6189  
Dakar-Etoile, Senegal  
Tel.: +221 33 822 44 84  
denis.depommier@cirad.fr

## Madagascar

François Monicat,  
Regional Director  
Ampandrianomby, BP 853  
Antananarivo, Madagascar  
Tel.: +261 20 22 406 23  
francois.monicat@cirad.fr

## Americas

### *Central America*

Bruno Rapidel,  
Correspondent in Costa Rica  
CATIE, Departamento de  
Agricultura y Foresteria  
CATIE 7170, Cartago  
Turrialba, 30501 Costa Rica  
Tel.: +506 25 58 25 99  
bruno.rapidel@cirad.fr

### *Brazil*

Bernard Mallet,  
Regional Director  
SHIS-QI 23, Bl. B. Ed. Top 23  
71660-120 Brasília DF, Brazil  
Tel. : +55 61 33 66 11 32  
bernard.mallet@cirad.fr

### *United States*

Jill Barr,  
Correspondent assigned  
to the World Bank  
and the Inter-American  
Development Bank  
Development Research Associates  
8313, Woodhaven Blvd  
Bethesda 20817, Maryland  
USA  
Tel.: +1 301 365 68 55  
jbarr@cirad.fr

## Asia

### *Continental Southeast Asia*

Jean-Charles Maillard,  
Regional Director  
CIRAD, Bureau 102, Bâtiment 2G  
Cité diplomatique de Van Phuc  
298 Kim Ma  
Hanoi, Vietnam  
Tel.: +844 3734 6775  
jean-charles.maillard@cirad.fr

Antoine Leconte,  
Correspondent in Thailand  
CIRAD Office  
Research and Development  
Building  
3rd floor, Kasetsart University  
10900 Bangkok, Thailand  
Tel.: +66 29 42 76 27 ext. 105  
antoine.leconte@cirad.fr

## India

Typhaine Loyer,  
INRA-CIRAD Correspondent  
Scientific Department of  
the French Embassy in India  
2, Aurangzeb Road  
110 011 New Delhi, India  
Tel.: +91 11 30 41 00 08  
typhaine.loyer@paris-inra.fr

### *Southeast Asian Island Countries*

Gilles Saint-Martin,  
Regional Director  
Plaza Bisnis Kemang, 3rd floor  
Jalan Kemang Raya 2  
12730 Jakarta Selatan, Indonesia  
Tel. : +62 21 719 90 67 /  
+62 21 719 46 01  
gilles.saint-martin@cirad.fr

### *China*

Zheng Li,  
INRA-CIRAD Permanent  
Representative  
507 Tower A, Fuhua Mansion  
8, Chaoyangmen North Avenue  
100027 Beijing, China  
Tel.: +86 10 6554 1871  
zhengliinra@sohu.com

### *Oceania*

Régis Goebel,  
Correspondent in Australia  
PO Box 86  
50, Meiers Road  
Indooroopilly Qld. 4068,  
Australia  
Tel.: +61 7 3331 3309  
francois-regis.goebel@cirad.fr



Production: Communication Service

Coordination and texts [French version]: Martine Lemaire,  
Danielle Barret [Indicators chapter], with the help of Christine Nouaille

Translation: Anna Kiff, Andrew Lewer

Graphic design and layout: Patricia Doucet

Coordination support: Christiane Jacquet, Véronique Nardini,  
Laurence Dedieu

Cover illustration: Nathalie Le Gall

Printing: Impact Imprimerie, Saint-Gély-du-Fesc  
Printed with vegetable inks on paper from sustainable forests

Legal deposit: June 2011



WORKING TOGETHER FOR TOMORROW'S AGRICULTURE



**cirad**

AGRICULTURAL RESEARCH  
FOR DEVELOPMENT

42, rue Scheffer . 75116 Paris  
FRANCE

www.cirad.fr

