

Projects funded in 2007 (Summaries)

No	Full name
07001 Completed	The role of BoIA-like proteins in iron homeostasis and iron-sulfur cluster biogenesis in <i>Arabidopsis</i>
07004 Completed	Automated identification of weed species in Camargue rice fields using techniques for the recognition of visual content
07010 Completed	Genetic analysis of cadmium accumulation in lettuce (<i>Lactuca sativa</i>)
07012 Completed	Unravelling pathogenecity of <i>Xanthomonas albilineans</i> , an original model in plant pathology
07013 Completed	CIBA, International Advanced Biology Consortium, Agropolis/Embrapa initiative
07015 Completed	Analysis and assessment of the spatial and temporal variability of the vine water status at a micro-regional scale from ground based data and different spatial information sources.
07024 Completed	Auxin transport as a key regulator of root developmental responses to nitrogen in <i>Arabidopsis thaliana</i> and <i>Casuarina glauca</i> .
07030	Molecular, developmental and genetic studies on the fruit abscission process of oil palm (<i>Elaeis guineensis</i> Jacq.)
07032	Integration of genetic, genomic, and marker assisted selection approaches to construct a sustainable <i>Phytophthora</i> resistance in new cocoa varieties
07035	International Thematic School: "Agrobiodiversity: people and plants. Tools and analytical methods"
07036 Completed	Learning, Producing and Sharing Workshop (<i>Apprentissage, Production et Partage d'Innovations (Atelier APPRI)</i>): what tools can be used to strengthen capacity, accompanying measures, collective construction and the sustainable implementation of innovations in dry rural zones in Africa?
07042 Completed	The varietal diversification process in fig and olive in Morocco: an ethnobiological and genetic interdisciplinary approach
07044 Completed	Capitalization and capacity building on method to assess and develop agroforestry innovation in humid tropics (Africa and Mesoamerica)
07045 Completed	International symposium on 'Innovation and sustainable development', 2010
07047 Completed	Leaf growth and soil water deficit in <i>A. thaliana</i> and apple tree: The 3 dimensions
07049 Completed	The 'integrative biology' community in Montpellier - Perpignan – Avignon - 1st Languedoc Roussillon – Catalonia meeting on Integrative Plant Biology
07051 Completed	13th World Water Congress – Montpellier 1 – 4 September 2008

07054 Completed	Digital analysis of the stability of a forest slope with integration of the space-time dynamics of the stand
07057 Completed	Preparation of an approach for the Construction of Innovative Agro-ecological Intensification Systems to contribute to more sustainable agriculture (C-SIAD)
07058 Completed	Understanding emergence of infectious diseases: Linking genomic evolution to the evolution of virulence of a phytovirus during the course of adaptation to its environments
07059 Completed	Canopy Architecture modelling for improvement of Genotype-environment description from Remote sensing

Keywords:

IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*)

IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*)

STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*)

STDI-2 (Socio-Technical Dynamics of Innovation 2: *Agri-food innovations, food and non-food use of plant crops*)

STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Year of CfP: 2007

Project No: 07001 Completed

Project title: The role of BoIA-like proteins in iron homeostasis and iron-sulfur cluster biogenesis in <i>Arabidopsis</i>

Unit managing the project: BPMP (Plant Molecular Physiology and Biochemistry) (CNRS, INRA, SupAgro, UMII)

Project leader: Jean-François Briat (briat(a)supagro.inra.fr)

Country involved in the project: USA

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*)

Objectives:

Iron is essential for living cells because Fe-S clusters are major protein cofactors. However, iron is potentially deleterious for the cell due to its reactivity with oxygen. Thus, iron and oxygen metabolisms required being tightly coordinated.

Recent results obtained in yeast indicate that the protein BoIA may be involved in iron homeostasis. BoIA seems to operate by interacting with glutaredoxins (Grx), proteins emerging as redox sensors in animals. These data provide a unique link between iron metabolism and oxidative stress responses.

In *Arabidopsis*, proteins containing BoIA-domain are present both in the cytosol and in the chloroplast. The plastidial one is related to the Fe-S cluster biogenesis. It interacts with the Grx-domain of an enzyme involved in sulfur assimilation, leading to hypothesize that the interaction BoIA/Grx-domains is a common feature that integrates various signals. Regarding the cytosolic BoIA protein, no characterization has been obtained so far.

Also, the host laboratory (BPMP) has isolated loss of function ferritin mutants. Ferritins are plastid proteins able to store iron under a non toxic form (ie without reactivity with oxygen), which can be remobilised accordingly to metabolism needs. These mutants are affected in iron homeostasis.

The aim of the project is to study the role of BoIA and ferritins in iron homeostasis and in the biogenesis of iron-sulfur clusters, and to decipher the interactions between iron and sulphur metabolism. This work is done in collaboration with a laboratory from the University of Colorado.

Action carried-out and results obtained:

During its stay at BPMP, E Pilon-Smits prepared tools enabling to study the cytosolic BoIA protein : mutant isolation, BoIA cDNA cloning in various expression vectors (yeast, plant). Dr Pilon-Smits has also performed physiological studies using plant ferritin mutants. In particular, she studied the response of these plants lacking ferritins to various oxidative stress (low temperature, high light, methylviologen treatment). She measured the impact of these conditions on plant biomass. She then performed a molecular physiology study using these various genetic backgrounds under these various environmental conditions (photosynthetic activity measurement, determination of the activities of various enzymes involved in Fe-S cluster biogenesis or ROS detoxification, expression study of genes regulated by iron and / or oxidative stresses).

Publication:

Karl Ravet, Brigitte Touraine, Jossia Boucherez, Jean-François Briat, Frédéric Gaymard, Françoise Cellier (Feb 2009) Ferritins control interaction between iron homeostasis and oxidative stress in *Arabidopsis*. *Plant J.* 57(3):400-412

Prospects for the future:

Studies initiated in Montpellier by Dr. E Pilon-Smits are currently continued in both the USA and the French laboratories. BoIA protein characterisation in yeast and plant mutant studies are mainly performed in Montpellier, whereas the impact of the boIA mutation on the Fe-S cluster biogenesis is under study in Dr. Pilon-Smits laboratory at Fort Collins (USA). Results from these studies should lead to a joint publication in 2009. A joint review publication on the topic is currently under writing and will be published during the first 2009 semester in Current Opinion in Plant Biology. Finally, a third year graduate student at BPMP (Karl Ravet) will join E. Pilon-Smits laboratory in 2009 as a post-doc fellow, facilitating the development of the collaboration on a longer range period.

Total Agropolis Fondation funding: € 18,830 (salary for a junior fellow)

Funding categorie(s): Agropolis Fondation Junior Fellowship

Project duration: 1 December 2007 – 31 March 2008

Keywords: *Arabidopsis* – iron – sulphur – homeostasis – ferritins

Year of CfP: 2007

Project No: 07004 Completed

Project title: Automated identification of weed species in Camargue rice fields using techniques for the recognition of visual content

Unit managing the project: AMAP (botany and computational plant architecture) (CIRAD, CNRS, INRA, IRD, UMII)

Project leader: Daniel Barthélémy (barthelemy(a)cirad.fr)

Countries involved in the project: Philippines, India, Colombia, West Africa, Madagascar

Other research units from the Foundation's scientific network involved: Innovation

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*), IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*), STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*)

Objectives:

The difficulties encountered in taxonomic identification are known for being one of the major obstacles to the application of the Convention on Biological Diversity. Since this obstacle was shown at the Conference of the Parties, much effort has been devoted to disseminating taxonomic information and identification tools that are faster, more relevant and more effective.

Numerous text and photographic taxonomic databases have thus been generated and disseminated using New Information and Communication Technology (NICT). However, they are still difficult to use for reasons of their size and complexity.

This project is aimed at achieving the automatic identification of weeds in rice fields in the Camargue using appropriate algorithms and an image recognition system linked with a botanical taxonomic database. The work will be conducted on a limited flora in which we already possess great expertise and that comprises several thousand images. The research will be focused on the species shown in the book *Les plantes des rizières de Camargue*, published jointly by CIRAD, the Parc naturel régional de Camargue and the Centre français du riz.

It must make it possible to analyse the feasibility of an approach in a real case and develop generic methods for the automatic identification of plant species by means of a computer system of recognition of visual content. The results will form the basis for subsequent, more ambitious projects on the automated identification of weeds of tropical crops, invasive plants or the plant species that form various natural ecosystems, especially in the tropics.

A photographic database will be assembled using standardised illustrations of 178 weed species in Camargue rice fields. This database, together with the existing database for this flora, will be used by image recognition tools for the optimisation of the latter. Present tools will be appraised and improved using series of tests conducted jointly by data processing specialists, botanists and weed scientists. The results will be reported in publications drafted jointly by the various partners and a report on the databases and the tools developed will be published on the websites of the various participating bodies.

Action carried-out and results obtained:

A preliminary phase of this project consisted in setting up an acquisition protocol of weeds pictures, adapted to the evaluation of the visual search engine IKONA. The realization of this protocol as well as the computer processing of the results was made on a picture database of Orchids of Laos. A second phase of the project, consisted to adapt this protocol to the specific pictures of rice weeds,

that were made during regular missions conducted from June to October 2008. All images realized were then annotated and transferred to Imedia project-team through the visual search engine Ikona.

These results showed the high performance of global images descriptors on well standardized pictures, and less good results on non-standardized ones. Tests led with local descriptors (such as points of interest) showed in some cases good results, due to the fact that they allow to be free of the background' constraints, however there are until now no mathematical tools adapted to their evaluation for taxonomic identification.

All the results of the project were put on-line in the form of tables and graphics, to show the pertinence of the various descriptors methods on the various images types. Two different applications permit us to use on-line the visual search engine Ikona on picture archives produced within the framework of this project. The specific interface of the research engine allows furthermore to access on each image to the species descriptive page on the website of the weeds of the rice fields of the Camargue

Publication:

Le Bourgeois T., Bonnet P., Edelin C., Grard P., Prosperi J., Théveny F., Barthélémy D., 2008. L'identification des adventices assistée par ordinateur avec le système IDAO. Innovations Agronomiques, 3 : 167-175

Prospects for the future:

The results supplied within the framework of this project, allow to orientate our future researches for the adaptation of the visual research system Ikona for a more efficient taxonomic identification.

Activities are in progress for evaluation of a specific shape descriptor of leaves forms and to compare it with generic visual descriptors. The requests made with local descriptors of images seem to offer interesting perspectives for the extension of this approach, they must however be improved in order (i) to allow their exploitation and evaluation on a wider scale, (ii) to run in a simultaneous way with shape and colors descriptions, (iii) to allow the description of forms with local descriptors according to their respective geometrical position.

Our works also revealed the interest to be able to make combined request by texts and images, as well as to be able to make multi-class requests. The multi-class request (the possibility to search a species by several characters types, as leaves scans, flowers pictures, etc.) will be thus deeply studied within the framework of the project PI@ntNet. The learning techniques were not able to be estimated during the AF 07 004 project, they seem to be sharply able to improve the answers of the system, that's why exploitation of relevance feedback with points of interests is the object of a thesis subject financed by INRA and INRIA. These encouraging results on weeds species require additional researches that will be implemented within the framework of PI@ntNet. They have to allow the realization of a multiapproaches identification tool (visual, graphical and textual). The approaches recommended during these researches want to be the most generic as possible. That's why results of these works will also serve as base for the extension of this approach for the identification of plants and/or plants diseases, by several images types and of several identification characters.

Total Agropolis Fondation funding: € 15,547 (travel expenses, 3 months contract for an engineer, photographic equipment)

Funding categorie(s): Agropolis Fondation small grants (support for small exploratory, risky and innovative projects ("proof of concept", new frontier research, etc.)

Project duration: January 7 2008 – January 7 2009

Keywords: taxonomy – photography – database – weeds – rice field

Year of CfP: 2007

Project No: 07010 Completed

Project title: Genetic analysis of cadmium accumulation in lettuce (<i>Lactuca sativa</i>)

Unit managing the project: BPMP (Plant Molecular Physiology and Biochemistry) (CNRS, INRA, SupAgro, UMII)

Project leader: Pierre Berthomieu (berthomieu(a)supagro.inra.fr)

Country involved in the project: Tunisia

Other research units from the Foundation's scientific network involved: GAFL

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*)

Objectives:

The goal of this project is to identify the genetic determinants controlling cadmium accumulation in lettuce as a first step towards the fine mapping of these determinants and the positional cloning of the genes underlying them.

Cadmium is a widespread metallic trace element whose concentration increases in cultivated soils. This has detrimental consequences in terms of food security. Genes proposed to control cadmium accumulation in plants have been identified mainly from functional studies performed in yeast up to now. The validation of the role of these genes in plants is still very limited. Very few (if any) mechanisms have been described as being possibly involved in the control of cadmium accumulation in plants in general. Lettuce (*Lactuca sativa*) can be characterised by a high ability to accumulate cadmium in its tissues. It is a good model both for studying the determinism of cadmium accumulation in plant tissues and for developing breeding strategies aimed at limiting cadmium accumulation in edible tissues of a crop species. The overall goal of this project is to characterise mechanisms underlying cadmium accumulation in lettuce and to identify the corresponding genetic determinants. The investigators have started to characterise the genetic diversity with respect to cadmium accumulation within the lettuce species, and this work has revealed a marked variability between lettuce varieties. The objective of this project is to further track the causes of the observed inter-varietal differences through physiological and molecular characterisations.

For this, genetic crosses between genotypes displaying extreme phenotypes to analyse the genetic bases of the character will be made. F2 populations from at least three different crosses are to be produced. Around 100 individual plants from each of these populations will be screened for cadmium accumulation following the standardised procedure established in the group. Genetic analysis of the data will be performed to characterise the cadmium accumulation character. The first steps towards the mapping of the character will be started. DNA extracts will be produced for the parent lines of the crosses and for the F2 analysed plants. Genetic markers already described in the literature will be tested on these parent lines, and then on the F2 population if they reveal polymorphism. This work will be pursued by a complete mapping experiment.

Action carried-out and results obtained:

Lettuce is a species that accumulates relatively significant quantities of cadmium in its tissues. In terms of food safety, it is interesting to breed varieties accumulating the lowest contents cadmium as possible. We work on the character of cadmium accumulation in the roots on the one hand, and on the character of translocation of cadmium from the roots towards the shoot on the other hand. From a diversity analysis, lines presenting extreme phenotypes for these two characters had been identified. Genetic crosses between these lines had been produced. The objective of the present work was to analyze the segregation of the two characters studied in the F2 progenies issued from

the crosses between the accessions presenting the extreme phenotypes for each character considered. Both characters proved to have a complex genetic determinism. No phenomenon of transgression was highlighted. We then wished to map the locus controlling the two studied characters. After several experiments aiming at allowing to combine phenotypical characterization and DNA extraction on a same plant, DNA extractions were performed on the 300 F2 plants that resulted from the two genetic crosses and that were phenotypically analyzed.

Publication:

Walid Zorrig, Aïda Rouached, Zaigham Shahzad, Chedly Abdely, Jean-Claude Davidian, Pierre Berthomieu (Oct 2010) Identification of three relationships linking cadmium accumulation to cadmium tolerance and zinc and citrate accumulation in lettuce. *J. Plant Physiol.* 167(15):1239-1247

Prospects for the future:

The DNA samples were sent to Pr. R. Michelmore (UC Davis) who will carry out the genetic mapping of the locus controlling (i) the accumulation of cadmium in roots and (ii) the cadmium translocation from the roots towards the shoot. The awaited results are completely innovative, since no determinant controlling the accumulation of cadmium has to date been identified in any species through a direct genetics approach.

Total Agropolis Fondation funding: € 4,784 (predoctoral fellowship, travel expenses)

Funding categorie(s): Agropolis Fondation small grants (support to pre-doctoral students)

Project duration: 1 January 2008 – 31 August 2008

Keywords: cadmium accumulation – lettuce – *Lactuca sativa* – genetics – crosses – polymorphism - mapping

Year of CfP: 2007

Project No: 07012 Completed

Project title: Unravelling pathogenicity of <i>Xanthomonas albilineans</i> , an original model in plant pathology
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Unit managing the project: BGPI (Biology and Genetics of plant/pathogen interactions) (CIRAD, INRA, SupAgro)

Project leader: Monique Royer (monique.royer(a)cirad.fr)

Country involved in the project: USA

Subthematic axes: IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*)

Objectives:

The xylem of plants is invaded by numerous bacterial plant pathogens and symbionts. However, no or very few data are available to date regarding the mechanisms that confer the capacity of these pathogens to colonize the xylem of their host. The bacterium *Xanthomonas albilineans* is a systemic, xylem-invading pathogen that causes leaf scald disease of sugarcane. The symptoms of the disease vary from a single white line on the leaves to the death of the plant, via bleaching and necrosis of the leaves.

X. albilineans is a problem in over 60 tropical and subtropical countries which produce sugarcane. This bacterium produces a unique and specific toxin, called albicidin that causes leaf scald symptoms. Albicidin is a potent DNA gyrase inhibitor that inhibits the replication of proplastic DNA and consequently blocks the differentiation of chloroplasts. The albicidin biosynthesis genes were cloned and sequenced at UMR BGPI in collaboration with Professor Dean W. Gabriel from the University of Florida. Although albicidin genes are essential in pathogenicity of *X. albilineans*, other genes, so far unknown, also play an important role in host-pathogen interactions.

To facilitate the identification of these unknown pathogenicity genes, the entire genome of *X. albilineans* was recently sequenced at Genoscope (Evry, France). The analysis of this genome confirmed that *X. albilineans* is an original model system in the world of plant pathology. The size of this genome (3.7 Mb) is smaller than those of other *Xanthomonas* species (~ 5 Mb). This genome does not possess the type three secretion system that is required in plant pathogenic bacteria for injection of protein pathogenicity effectors into plant cells. Additionally, this genome possesses 754 open reading frames that have not been found in any other *Xanthomonas* species. The objective of UMR BGPI is to identify *X. albilineans* pathogenicity genes, giving rise to prospects for the design of new control methods of plant diseases.

The objectives of the present project are:

- to consolidate the existing collaboration between Cirad and the University of Florida by supporting a three months visit of a technician of Cirad who will learn different molecular methods and tools recently developed there
- to structure a new collaboration with the group of Professor Caitilyn Allen from the University of Wisconsin–Madison that has the scientific knowledge to study colonization of plants by pathogenic bacteria. In this context, Dr Monique Royer from Cirad in Montpellier and Dr Philippe Rott from University of Florida will go for one week to the University of Wisconsin-Madison.

Action carried-out and results obtained:

Action 1: Isabelle Pieretti spent three months at the University of Florida from 1st February to 30th April 2008 under the supervision of Prof. Dean W. Gabriel. Her studies allowed us to identify genes that are specific to a highly pathogenic strain of *X. albilineans* using the Suppression subtractive hybridization technique. This training in the USA also allowed I. Pieretti to improve her oral and written English language skills.

Result of Action 1: Suppression subtractive hybridization (SSH) is a differential screening method coupled to polymerase chain reaction (PCR) that was developed to compare bacterial genomes. It can be useful to identify unique or strain-specific DNA fragments when comparing two bacterial genomes that are relatively close. We applied SSH to two strains of *Xanthomonas albilineans* from Florida (XaFL07-1 and Xa23R1) that belong to different genetic and pathogenicity groups, in order to identify genes putatively involved in leaf surface and vascular colonization of sugarcane plants. Highly pathogenic strain XaFL07-1 was used as the tester strain. This strain belongs to the same genetic group as strain GPE PC73 of *X. albilineans* from Guadeloupe whose genome was recently sequenced and annotated. Strain Xa23R1 is less pathogenic than strain XaFL07-1 and is not spread aerially. It was used as the driver (subtractive) strain, i.e. the control DNA against which the tester strain DNA was compared. A library of 576 clones enriched for XaFL07-1 DNA was generated with the PCR-select Bacterial Genome Subtraction Kit (Clontech). After verification by Southern blot hybridization, 188 clones were found specific for strain XaFL07-1. These 188 clones were sequenced and the sequences were then blasted against the complete genome of *X. albilineans* strain GPE PC73. Comparative analyses of these sequences resulted in the elimination of 83 XaFL07-1 sequences because they were absent in the genome of pathologically similar strain GPE PC73, or because they were plasmid, phage or transposase sequences. The remaining 105 sequences were chosen to be validated by PCR and for further analysis, especially functional genetics in strain GPE PC73. These sequences include genes encoding for hemagglutinins and hemolysins, a TonB-dependant outer membrane receptor, a large membrane receptor, a DNA methyltransferase, and several permeases or transporters.

Action 2: Monique Royer and Philippe Rott visited the group of Prof. Caitilyn Allen at University of Wisconsin-Madison from 15th to 18th of April 2008. During her stay in the USA, Monique Royer also visited the group of Prof. Dean W. Gabriel at University of Florida.

Result of Action 2: M. Royer and P. Rott discussed with C. Allen the work that was performed on *X. albilineans* at UMR BGPI in Montpellier (M. Royer) and at University of Florida in Gainesville (P. Rott), in order to develop a new collaboration. It was agreed that Prof. C. Allen will spend a sabbatical of six months in Montpellier, from January to June 2009. During this period, Prof. C. Allen will teach classes in plant pathology at Montpellier SupAgro and will perform research studies on *X. albilineans* at UMR BGPI. Prof. C. Allen will especially try to identify genes induced in *X. albilineans* during colonization of sugarcane by this pathogen, using DNA microarrays. This project was submitted to and accepted by RTRA in the frame of RTRA's APP 2008. M. Royer and P. Rott gave a seminar to the plant pathology department of University of Wisconsin that was entitled: "Genomics and functional genomics of *Xanthomonas albilineans*, an unusual xanthomonad that causes leaf scald disease of sugarcane". M. Royer and P. Rott also met researchers of the departments of pathology and microbiology of the University of Wisconsin-Madison who specialize in the biosynthesis of antibiotics and the finding of new molecules produced by various microorganisms.

Prospects for the future:

The work performed by Isabelle Pieretti allowed us to identify several genes putatively involved in pathogenicity of *X. albilineans*. Professeur Caitilyn Allen will be hosted by UMR BGPI from January to June 2009 in the frame of a new RTRA project (N° 0802-012). This new project will allow us to identify additional pathogenicity candidate genes. All these new candidate genes will be further investigated, especially by functional analyses of *X. albilineans* strain GPE PC73. These studies will be performed in the frame of collaborations with University of Florida and University of Wisconsin-Madison.

Total Agropolis Fondation funding: € 12,749 (travel expenses)

Funding categorie(s): Agropolis Fondation small grants (overseas travel grants for doctoral and post-doctoral scientists, development of a project)

Project duration: 2 January 2008 – 30 June 2008

Keywords: *Xanthomonas albilineans* – pathogenicity – plant – toxins – sugarcane – leaf scald disease

Year of CfP: 2007

Project No: 07013 Completed

Project title: Consortium International en Biologie Avancée (CIBA, International Advanced Biology Consortium), Agropolis/Embrapa initiative

Unit managing the project: AGAP (Genetic improvement and Plant adaptation) (CIRAD, INRA, Montpellier SupAgro)

Project leader: Marc Berthouly (berthouly(a)cirad.fr)

Country involved in the project: Brazil

Research units from the Foundation's scientific network involved: AMAP, BGPI, DIADE

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*), IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*)

Objectives:

Embrapa (the Brazilian Agricultural Research Corporation) has long collaborated fruitfully with French agricultural research institutes such as CIRAD, IRD and INRA. Together, Embrapa and the latter institutions conduct scientific and technical cooperation operations in the fields of agriculture and natural resources, aiming at increasing knowledge in relation with the sustainable development of agriculture. One of the results of the collaboration operations was the signing of an agreement between Agropolis and Embrapa for the installation of the Labex (Embrapa external laboratory) in Montpellier in early 2002. The prime objective of the Labex is to provide a scientific and technological watch by posting experienced scientists to cutting-edge laboratories in Europe. Advanced biology is one of the priority lines followed by the Labex.

The objective of this programme is to set up research projects backed by the Consortium International en Biologie Avancée (CIBA). The CIBA consortium is an Agropolis/Embrapa initiative aimed at achieving an effective sustained international scientific and technical cooperation strategy. Joint funding should make it possible to establish an entity capable of studying and using the diversity of plant genetic resources and to identify the genes and characters of agricultural interest that are essential for breeding programmes in tropical and Mediterranean agriculture.

The holding of two meetings during a 24-month period is planned—the first was in 2008 to reply to ANR 2008 call for bids and the second in 2009 to reply to the call for bids of the 7th European Union FPRD. The meetings are held in Montpellier and in Brazil and attended by Embrapa and Agropolis scientists to identify projects of common interest for drafting bids. Each meeting can be organised in the form of two theme workshops (tolerance to drought and resistance to fungi and nematodes) with scientific presentations open to the public.

Action carried-out and results obtained:

Since the CIBA began, Embrapa and Agropolis have made efforts to extend the current portfolio of projects in the themes of the consortium. Accordingly, co-financed by Embrapa and Agropolis workshops have been used to promote the dynamics between research teams in Brazil and France, for the formatting of cooperative research on topics of common interest projects

A. The first meeting of CIBA realized in Brasilia through the funding of the RTRA and Embrapa to one side fully revealed the difficulties and constraints of funding international research (negative aspects) and the other permit scientifically strengthen links between different teams (positive aspect).

Négatif Aspect: Despite the quality of the research it is difficult to obtain international funding or national on some plants (perennial) which are not considered as a model. More issues "policies" (inter-institutionnelles) are sometimes a hindrance to the consolidation of collaborations.

Positive Aspect: Although the number of projects for funding for 2008 type ANR, 7th Framework does not exist this meeting several positive aspects: **a.** It served together in excess of Embrapa, various federal institutions and universities Brazilian, giving his "governing" value to the Consortium. **b.** In the case of plants in particular she helped strengthen already existing links:

- **Palm**: the Embrapa has agreed to participate "OPGP" (results of the discussions and exchanges during the seminar) this project is coordinated by CIRAD (n. Billote) (10 partners). Each brings some 150,000 euros. The Embrapa signed and his entry will be effective in 2009

- **Cocoa**: Project ANR 2008 cacaobac : CIRAD/University genoscope/arizona, the Brazil will be associated with the project sequencing next year 2009

- Construction of a bank; Criollo cacao BAC sequencing and bioinformatics analysis end of Lac Cocoa Criollo BAC library construction; BAC-end sequencing and bioinformatic analyses.

B. The Second meeting of the CIBA was realized at Montpellier at the headquarters of Agropolis International in Montpellier 5-10 October 2009

The workshop has been very successful and to fully achieved its objective "articulation" Advanced plant biology research projects. These proposals aim to encourage a tripartite France/Brazil/Africa partnership by strengthening existing scientific interactions between France and Brazil.

As a result of the various discussions and conclusions made by the working groups some lines of actions could be defined:

- **to include the training in all the actions or activities of CIBA**: It was decided the need to establish a clear strategy to foster mobility (trade) and scientific training of researchers as part of the CIBA projects.

- **to favour the tripartite partnership in CIBA**: Search applications identified by the African colleagues present at the workshop are more adaptive nature and stress the emphasize to adjust the already developed methodologies, Brazil and France, to African conditions.

- **to favour the participation of African institutions in CIBA**: The CORAF by its leaders, showed the interest to participate and/or collaborate to the CIBA. Managers of the CORAF have proposed that the next workshop CIBA could be achieved in Africa. The CNPq, from its Director, is committed to finance part of this event.

It was suggested that, also the CORAF, CIBA include FARA (*Research Forum for agriculture in Africa*) as a potential partner. The FARA was created by three subregional organizations (CORAF, ASARECA and SADC) to mobilize resources, facilitate access to technologies, develop policies, strengthen the training of African countries and establishing strategic partnerships and alliances that promote agricultural research in Africa.

Another important Organization for CIBA is the AGRA (*Alliance for a green revolution in Africa*) that manages resources of *Bill & Melinda Gates Foundation*. The AGRA, jointly with the FARA, are currently the two institutions with capacity to finance projects r & d for Africa.

- **Meeting "out " of IV WORKSHOP CIBA**:

It was the first meeting of the Scientific Committee of CIBA consisting of: Philippe la Guerche (INRA), Jean-Christophe Glaszmann (Cirad), Vera Carvalho Alves and Mauro Carneiro (Embrapa), and José Osvaldo Siqueira (CNPQ). A report of the meeting should be distributed.

There is a meeting at the headquarters of Agropolis Fondation with Anne - Lucia Wack (Director General Agropolis Fondation); Oliver Oliveros (Senior officer International partnership Agropolis Fondation), Pedro Arcuri (Embrapa-Labex-Europe Coordinator); José Osvaldo Siqueira (CNPQ program director) and Sandoval Carneiro Júnior (Director of international relations CAPES) to discuss the terms of an agreement concluded between the CAPES and Agropolis Fondation which aims to promote the mobility of researchers and postgraduate students Brazilian and French. Agropolis Fondation proposes also signing agreements with the CNPq for the networking of scientific projects.

When of a meeting with colleagues present Brazilian in the workshop, José Osvaldo Siqueira (CNPQ program director) announced a project partnership CNPq/Labex for the granting of scholarships (Ph.d. sandwich and post-doctoral) in the United States and Europe.

Prospects for the future:

Actions necessary to promote the CIBA: Need a debate internal in Embrapa on the concept of "Advanced biology" and the applicability of research in this area for genetic improvement and the production of tropical plants. Therefore, it is clear that genetic improvement is integral and primary target projects within the framework of the CIBA. He raised the issue of the difficulty of CIBA project by the national bodies (France) and international finance because these organizations do not consider tropical crops as a priority.

Creating a CIBA WEB site (2010), with specializing service in CIRAD (B. Girardot)

Need to search for a permanent funding for research and training: an initiative was launched to next to the Embrapa .the same thing should soon be placed parallel to the next of Agropolis

Total Agropolis Fondation funding: € 50,000 (travel expenses)

Funding categorie(s): Agropolis Fondation small grants (support to prepare applications for national or international calls for proposals (e.g. ANR and EU FPs)

Project duration: January 2 2008 – December 5 2009

Keywords: advanced biology - Agropolis – Embrapa – sustainable development - CIBA

Year of CfP: 2007

Project No: 07015 Completed

Project title: Analysis and assessment of the spatial and temporal variability of the vine water status at a micro-regional scale from ground based data and different spatial information sources.

Unit managing the project: LISAH (Laboratory of Soils, Agrosystems, Hydrosystems interaction studies) (INRA, IRD, SupAgro), and UMR ITAP (Cemagref)

Project leader: Philippe Lagacherie (LISAH, lagache(a)supagro.inra.fr) and Bruno Tisseyre (ITAP)

Country involved in the project: Australia

Research units from the Foundation's scientific network involved: LESPE

Subthematic axes: STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*)

Objectives:

Monitoring vine water status both temporally (through the season) and spatially is of great importance for growers and winemakers. The vine water status is critical at all stages of production as it impacts on vine vigour, yield and harvest quality. It therefore constitutes one of the main decision support information for the growers to manage the vines. Correct and timely knowledge of vine water status should be the basis for any within season management aimed at optimising crop yield and quality. The opportunity to manipulate management is particularly relevant in irrigated vineyards where growers have some control over soil moisture conditions. Beyond these vine production issues, knowledge of the spatial and temporal variations of vine water status is also a prerequisite for evaluating water resource and predicting its evolution with climate changes in mediterranean areas where vine is a dominant crop.

The plant water status however varies significantly over time depending on the climate of the year. It also shows significant spatial variability within vineyards and vineyard blocks depending on soil (landscape) spatial variability. It has therefore traditionally been a very difficult and costly parameter for growers to measure and manage. As a consequence, studies in this area have been conducted at either very broad scales (regional) or very fine scales (plant-specific).

Broad-scale (regional) studies utilise climatic and landscape data that focus on trends across regions and average responses to model climatic and environmental impacts on vine water status and on grape production. The resulting models lack sufficient spatial accuracy to be used for management at a vineyard level which requires an understanding of variation at this intermediate scale. Conversely, a number of research has focused on point measurements of vine-soil-climate interactions at the plant-scale. This provides good information about interactions involved, however the sampling strategy is often poorly designed or of insufficient density to extrapolate this information to the vineyard block or whole vineyard level.

Existing models are thus too inflexible to either upscale or downscale to the vineyard level. The aim of this project is to develop a new model incorporating recent advances from precision agriculture and pedometrics in sensing and mapping, in order to provide information at a scale compatible with vineyard management.

Experiments will be carried out on the experimental vineyard of Pech-Rouge (Aude) where all the data sources required to test the approach and to design the model are already available.

This model will have several benefits:

- deliver a more timely and more accurate information on vine water status to growers, which will help them to optimise grape yield and quality (better management leads to better wine and a more sustainable and competitive industry)
- allow for finer-scale modelling of the impact of climate change on viticulture production and potentially to build a model to assist the location and design of new vineyard plantings or replantings.
- assist growers and regulators to better understand the potential effect of irrigation schemes on grape production in Languedoc by modelling irrigation at a vineyard scale.

Action carried-out and results obtained:

Two broad, inter-linked research domains were undertaken within this project. These related to a) the spatial and temporal evolution of vine water stress on the Languedoc viticulture plain and b) how information relating to vine water stress can be used to digitally map sub-soil properties at a regional scale.

The first year of research concentrated primarily on the first domain - with an indepth analysis of what environmental factors drive or indicate vine water stress and how the spatial variation in vine water stress is affected by the scale or 'footprint' of measurement (point, field, vineyard etc). This showed that data related to the vegetative expression of the vine were the best indicators mid season and soil type became predominantly more important as the season progressed. We also demonstrated that the variation within a field was significant enough to be considered for differential (site-specific) management. Two spatial models were proposed and published. These models, based on either absolute or relative values, were able to effectively 'spatialise' the variation in vine water stress at a field-scale from a real-time point reference value at an accuracy that was ~50% of the error currently accepted by growers.

Temporal modelling of the evolution in vine water stress was performed in the second year and was aimed at reducing or eliminating the need for the reference measurement in the spatial model. Previously observed linear relationships between points at a sub-field scale were demonstrated to occur at the inter-field scale, even when fields are not contiguous. Thus, if a reference measurement is taken, the data can be extrapolated to other fields, thereby minimising sampling requirements. These linear inter-field relationships were strongest between fields on common soil types but appeared to be sufficiently strong between fields on different soil types for management purposes, provided there were no external soil moisture effects in one of the fields e.g. access to a water table or preferential sub-surface flow. Season water stress evolution was also modelled directly from climatic data at the research site (Gruissan, Aude, France). A model such as this may remove the need for any physical measurements. Prediction accuracies from the temporal model over 6 seasons (2003-2008) were again considerably less than current accepted industry standards. Such a model is dependent on soil conditions, meso-climatic effects and measurement, which are all location specific. Preliminary work has shown that transfer of the temporal model to two other distant (~100 km away) locations was possible with an easily derived local linear calibration co-efficient.

The different spatial and temporal models are currently being combined and analysis is underway to determine the sensitivity and accuracy of the different spatio-temporal models and in particular if the prediction errors of a combined model are sufficient for industry adoption.

Research in the second domain - digital soil mapping - was primarily carried out in the second year. This research built on a novel approach developed at UMR LISAH for mapping evapotranspiration (ET) at a regional scale. Modelling exercises demonstrated that the addition of the ET data, which indicates plant functioning, improved predictions and mapping of soil depth (available soil water capacity) over modelling with conventionally used environmental and topographic covariates. This modelling was performed at the catchment scale (the Peyne catchment, Hérault, France) and demonstrated that in monoculture situations, plant growth covariates are able to improve the accuracy and resolution of predictions of subsoil properties that are not themselves directly measured by remote sensors. In particular, ET, which is an indicator of plant water stress but not widely available or used for mapping, is useful for modelling and mapping soil depth/available water capacity.

In addition to this work, Dr Taylor was also involved in several collaborations with partners located at SupAgro as well as overseas. These were predominantly in the realm of Precision

Agriculture/Horticulture. Details of the different research streams and topics are given in the attached figure.

Publications:

Taylor, J.A. Coulouma, G., Lagacherie, P. and Tisseyre, B. (2009) Mapping soil units within a vineyard using statistics associated with spatial data and factorial discriminant analysis. *Geoderma*, 153, p278-284 (doi:10.1016/j.geoderma.2009.08.014)

Taylor, J.A. Acevedo-Opazo, C., Ojeda, H. and Tisseyre, B. (2009) Identification and significance of sources of spatial variation in grapevine water status. *Aust. J. Grape Wine Res.* 16(1) p218-226 (doi:10.1111/j.1755-0238.2009.00066.x)

Pedroso M., Taylor, J.A., Tisseyre, B., Charnomordic, B and Guillaume, S. (2009) A segmentation algorithm for the delineation of management zones. *Comput. Electron. Agric.* 70, p199-208 (doi:10.1016/j.compag.2009.10.007)

Acevedo-Opazo, C., Tisseyre, B., Taylor, J.A., Ojeda, H. and Guillaume, S. (2010) A model for the spatial prediction of water status in vines (*Vitis vinifera* L.) using high resolution ancillary information. *Precis. Agric.* (On-line First) (doi: 10.1007/s11119-010-9164-7).

Moacir Pedrosoa, James Taylor, Bruno Tisseyre, Brigitte Charnomordic, Serge Guillaume (2010) A segmentation algorithm for the delineation of agricultural management zones. *Computers and Electronics in Agriculture*. Volume 70, Issue 1, January 2010, Pages 199-208

Prospects for the future:

In the short-term (1-2 years), Dr Taylor is continuing to work with Drs Tisseyre and Lagacherie on several journal articles arising from the research undertaken during the Post-doctoral Fellowship. He is also working on a second article with collaborators in UMR ITAP and ASB regarding the published segmentation algorithm. In the medium term (3-5 years), the project partners are planning to submit funding applications at a European level to further develop the work undertaken on digital soil mapping with vegetative covariates. Dr Taylor is also involved in an on-going project with Dr Tisseyre and IFVV which is investigating water stress issues at the Syndicat level within an AOC defined terroir. All parties hope that in the longer term (+5 years) there will continue to be an association between Dr Taylor and UMR LISAH and UMR ITAP.

Total Agropolis Fondation funding: € 111,632 (salary for a post-doctoral fellow, travel expenses, running costs)

Funding categorie(s): Agropolis Fondation post-doctoral fellowship

Project duration: 2 January 2008 – 21 October 2010

Keywords: vine – vineyard - water status – modelling – irrigation

Year of CfP: 2007

Project No: 07024 Completed

Project title: Auxin transport as a key regulator of root developmental responses to nitrogen in *Arabidopsis thaliana* and *Casuarina glauca*.

Unit managing the project: BPMP (Plant Molecular Physiology and Biochemistry) (CNRS, INRA, SupAgro, UMII)

Project leader: Alain Gojon (gojon(a)supagro.inra.fr)

Country involved in the project: UK

Research units from the Foundation's scientific network involved: AGAP, DIADE

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*)

Objectives:

One main characteristic of plants is their ability to react to a highly fluctuating environment by initiating profound developmental changes. This is particularly true in response to nutrient stress, one of the most frequent abiotic constraints plants have to face. Nutrient stress has profound effects on root system architecture, which are triggered by specific signaling pathways. In the case of nitrate (NO₃⁻) and phosphate (PO₄), these signaling pathways have been shown to involve auxin, a key phytohormone in root development. Auxin plays a particularly central role in lateral root (LR) formation and growth, which depend on the establishment of local auxin gradients at the site of LR initiation, and within the young emerging LR.

The scope of the project is to investigate how nitrogen availability modulates local auxin gradients within the root system, and how this results in changes in root development. Two biological models will be used: i) *Arabidopsis thaliana*, where the aim is to determine how nitrate (NO₃⁻) sensing by NO₃⁻ transporters regulates the root system architecture through altered auxin transport, and ii) *Casuarina glauca*, a tropical plant, where the aim is to determine the role of auxin transport in the formation of nitrogen-fixing nodules triggered by nitrogen deficiency.

The common question addressed with both species is: how does nitrogen modulate auxin transport in the root system to regulate LR growth (in *Arabidopsis*) or the formation of a modified LR (the actinorhizal nodule) in *Casuarina*? This will extend the knowledge obtained in the model species *A. thaliana* to a tropical plant that plays an important role as a pioneer species for the rehabilitation of poor or degraded sites in tropical and subtropical countries.

The investigation of auxin gradients in root tissues is challenging because of the difficulty to determine local auxin concentrations and fluxes. This project aims at overcoming this difficulty through the development of complementary approaches

Action carried-out and results obtained:

The aim of this project was to investigate how nitrogen availability modulates local auxin gradients within the root system, and how this results in changes in root or nodule development. Two biological models were used: i) *Arabidopsis thaliana*, where the aim is to determine how nitrate (NO₃⁻) sensing by the AtNRT1.1 NO₃⁻ transporter regulates the root system architecture through altered auxin transport, and ii) *Casuarina glauca*, where the aim is to determine the role of auxin transport in the formation of nitrogen-fixing nodules triggered by nitrogen deficiency.

In *Arabidopsis*, we previously found that the nitrate transporter NRT1.1 modulates the growth rate of lateral roots because it mediates a nitrate-regulated auxin transport (briefly, NRT1.1 transports auxin in the absence of nitrate but not when nitrate is available as a substrate). NRT1.1 slows

down growth of the lateral roots at low external nitrate concentration because it lowers auxin accumulation in these roots. Thus, auxin accumulates at a high level only in lateral roots in contact with a high nitrate concentration. Because auxin enhances lateral root growth, this allows the plant to specifically promote this growth in the nitrate-rich patches of the soil. However, the mechanism by which NRT1.1 prevents auxin accumulation in lateral roots was unknown. The work done by F. Perrine-Walker allowed to characterize this mechanism. The localization of the NRT1.1 protein (generation and investigation of NRT1.1-GFP transformants) showed that it is specifically expressed in tissues involved in the basipetal transport of auxin out of the lateral root toward the inner tissues of the primary root. Two additional findings were made thereafter: (1) The expression of the NRT1.1 protein is repressed by nitrogen, and (2) nitrate affects the expression of several other auxin carriers in the lateral roots (LAX3, PIN1 and PIN2). In more detail, nitrogen starvation results in an earlier expression of NRT1.1 during the initial stages of lateral root primordia development. This earlier expression of NRT1.1 seems to be associated with primordia abortion, suggesting that in addition to regulating lateral root growth rate, NRT1.1 also controls a key step in the initial development of lateral root primordia. On the other hand, the effect of nitrate on the expression of LAX3 (stimulation) and PIN1-2 (repression) shows that nitrogen exerts a general control on the overall auxin traffic in lateral roots, beyond the specific action of NRT1.1. These new data are original and raise additional hypotheses. Complementary experiments are currently performed to strengthen these findings.

In *Casuarina*, actinorhizal nodule formation in conditions of nitrogen deprivation and in symbiosis with the bacteria Frankia is associated with the expression of the CgAUX1 auxin influx carrier gene in infected plant cells. Using biochemical techniques, we were able to show that nodules contain more auxin (both indole acetic acid (IAA) and phenyl acetic acid (PAA)) than non infected roots. Immunolocalization of IAA and PAA in nodules showed the preferential accumulation of auxin in Frankia-infected cells. Moreover, auxin efflux carriers of the PIN family were immunolocalised in *C. glauca* nodules and were found to be specifically expressed in non-infected cortical cells. Modelling auxin fluxes within nodules showed that this specific expression of auxin transporters (both CgAUX1 and PIN-like transporters) restrict auxin accumulation to Frankia-infected cells. Furthermore, Frankia genomes mining and gene expression studies indicate that Frankia produces auxin (both IAA and PAA) in planta. Altogether, our results indicate a link between auxin and symbiotic infection.

In summary, the experimental work has been successful. This was due to the high efficiency of F. Perrine-Walker, who could only devote one-year work to each part of the project. The tight connection between the two parts of the project was ensured by the fact that the same questions (local auxin accumulation, expression of AUX1 and PIN carriers) were addressed in both species.

Publications:

Gojon A, Krouk G, Perrine-Walker F, Laugier E. 2011. Nitrate transceptor(s) in plants. *J Exp Bot* 62: 2299-2308.

Krouk G, Ruffel S, Gutiérrez RA, Gojon A, Crawford NM, Coruzzi GM, Lacombe B. 2011. A framework integrating plant growth with hormones and nutrients. *Trends Plant Sci* 16: 178-182.

Perrine-Walker F, Doumas P, Lucas M, Vaissayre V, Beauchemin NJ, Band LR, Chopard J, Crabos A, Conejero G, Péret B, King JR, Verdeil JL, Hocher V, Franche C, Bennett MJ, Tisa LS, Laplace L. 2010. Auxin carriers localization drives auxin accumulation in plant cells infected by Frankia in *Casuarina glauca* actinorhizal nodules. *Plant Physiol* 154: 1372-1380.

Gabriel Krouk, Benoît Lacombe, Agnieszka Bielach, Francine Perrine-Walker, Katerina Malinska, Emmanuelle Mounier, Klara Hoyerova, Pascal Tillard, Sarah Leon, Karin Ljung, Eva Zazimalova, Eva Benkova, Philippe Nacry, Alain Gojon (Jun 2010) Nitrate-regulated auxin transport by NRT1.1 defines a mechanism for nutrient sensing in plants. *Dev. Cell* 18(6):927-937

Péret B, De Rybel B, Casimiro I, Benková E, Swarup R, Laplace L, Beeckman T, Bennett MJ. 2009 *Arabidopsis* lateral root development: an emerging story. *Trends Plant Sci.* 14: 399-408.

Prospects for the future:

In *Arabidopsis*, additional work is scheduled to determine whether NRT1.1 governs initial stages of lateral root development, in addition to modulating the growth rate of these roots as a function of nitrate availability (time-lapse studies of NRT1.1 expression in lateral root primordia, coupled with

determination of abortion rate). The effect of nitrate on the expression of the other auxin carriers will be carried out in a NRT1.1 mutant genetic background, to determine whether this effect is dependent on NRT1.1.

In *Casuarina*, further work is planned to analyse the role of auxin during the infection process. We will use a 15K *Casuarina* microarray to study changes in gene expression in nodules treated with an inhibitor of auxin influx (NOA) versus non treated nodules. This will help us identify symbiotic genes regulated by auxin. Moreover, we recently generated a dominant negative version of an auxin response regulator (CgIAA7-DN). We will express this gene in Frankia infected cells to inhibit auxin responses specifically in those cells and study the effects on the symbiotic interaction.

Total Agropolis Fondation funding: € 117,265 (Salary for a post-doctoral fellow, travel expenses, running costs, participation in a workshop)

Funding categorie(s): Agropolis Fondation post-doctoral fellowship

Project duration: 1 March 2008 – 24 November 2010

Keywords: auxin - *Arabidopsis thaliana* - *Casuarina glauca* – root development – nitrogen

Year of CfP: 2007

Project No: 07030

Project title: Molecular, developmental and genetic studies on the fruit abscission process of oil palm (<i>Elaeis guineensis</i> Jacq.)
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Unit managing the project: DIADE (Diversity, Adaptation and development of Plants) (IRD, UMII)

Project leader: Timothy Tranbarger (timothy.tranbarger(a)ird.fr)

Country involved in the project : Thailand

Research units from the Foundation's scientific network involved: AGAP

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*)

Objectives:

Fruit development and ripening are unique biological processes of flowering plants in addition to being essential for both human and animal diets. Oil palm (*Elaeis guineensis* Jacq) belongs to the *Arecaceae* family and its fruit is the number one source of edible vegetable oil worldwide. While increases in yields are clearly possible with oil palm, one factor that limits overall yield gains is the loss due to non-synchronized ripening and subsequent shedding of the ripest fruit before harvest. In this context, the current project has the objective of working towards a molecular understanding of the ripening and abscission processes that lead to oil palm fruit shedding, as a basis for achieving higher yielding oil palm plantations.

Advances in the molecular research on abscission have been hampered by both the lack of suitable experimental genetic material (i.e. abscission mutants or genotypes) and the limited quantities of abscission zone (AZ) cells available in model species to do molecular approaches. Research with model plants, such as tomato, has shown that the process of fruit shedding is a highly coordinated developmental process that involves the AZ. The specialization of the AZ that develops in the pedicel of the flower becomes apparent later during fruit development when a subpopulation of these cells functions to respond to signals originating from the ripening fruit. These signals are perceived and lead to AZ specific expression of a number of abscission related genes, some of which encode cell wall modifying enzymes that function to decrease the adhesion between cell walls of adjacent AZ cells. The activity of these enzymes on the cell walls of the AZ leads to adjacent cells being separated along the base of the fruit stalk and the fruit is shed. Oil palm provides an excellent model system in which both genetic materials with different abscission characters are available and AZ tissue samples from developing flowers or ripening fruit can be dissected in large enough quantities for cDNA library construction. Finally, the candidate genes discovered to be associated with the oil palm abscission process can be tested for use in molecular assisted selection programs.

This study will focus on the molecular and cellular characterization of the oil palm abscission zone from its differentiation during flower formation to the cell separation stage during fruit shedding.

Total Agropolis Fondation funding: € 120,000 (doctoral student fellowship, travel expenses, running costs)

Funding categorie(s): Agropolis Fondation doctoral fellowship

Project duration: 2 February 2008 – 30 April 2011

Keywords: oil palm – abscission zone – fruit ripening – shedding – cDNA libraries

Year of CfP: 2007

Project No: 07032

Project title: Integration of genetic, genomic, and marker assisted selection approaches to construct a sustainable *Phytophthora* resistance in new cocoa varieties

Unit managing the project: AGAP (Genetic improvement and Plant adaptation) (CIRAD, INRA, Montpellier SupAgro)

Project leader: Claire Lanaud (claire.lanaud(a)cirad.fr)

Countries involved in the project: Trinidad and Tobago, Ivory cost, Cameroon, Brasil

Research units from the Foundation's scientific network involved: BGPI

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*), IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*)

Objectives:

Oomycetes and especially *Phytophthora* are a permanent and serious threat to agriculture. *P. palmivora*, the most common species in the tropics and sub-tropics, attacks approximately 150 plant species, including cacao (*Theobroma cacao*).

Cocoa is mainly produced on smallholdings. It is estimated that approximately 14 million people around the world work in cacao plantations. *Phytophthora* sp. are responsible worldwide for 30% of losses in cocoa production.

Chemical treatments can be efficient but are pollutive and often too expensive. Several sources of genetic resistance exist in *T. cacao*, and an accumulation of different resistance genes is a better way to establish a sustainable *Phytophthora* resistance. A genetic QTL (Quantitative Trait Loci) approach is the most efficient way to identify the genetic bases of *Phytophthora* resistance and the different genetic sources of resistance genes among several resistant progenitors. High density maps have been previously established by the DAP team, and several QTLs for *Phytophthora* resistance identified in a number of genotypes confirming the quantitative nature of this resistance. However, these studies have to be completed for other important sources of resistance. This approach also provides markers for accumulation of resistance genes in new varieties by Marker Assisted Selection (MAS).

This project presents an integrated approach associating genetics and genomics, and marker-assisted breeding activities.

The specific objectives of this study are:

- to complete the identification of genome regions (QTL) involved in *Phytophthora* resistance.
- to identify candidate genes involved in *Phytophthora* resistance by integrating functional genomic and genetic mapping approaches.
- to validate the presence of favourable resistance QTL alleles identified in this project and in previous QTL studies on a resistant population collected farmers' fields in Cameroun
- to apply a marker assisted selection (MAS) in order to improve cocoa resistance to *Phytophthora*.

The search for candidate genes at the basis of *Phytophthora* resistance could provide more efficient tools to direct the accumulation of resistance genes and discover new source of resistance genes

among the germplasm collection. Moreover, a better understanding of *T. cacao* /*Phytophthora* interactions could also have a more general interest to understand other plant/*Phytophthora* interactions.

Total Agropolis Fondation funding: € 259,320 (salaries for 2 doctoral and 2 post-doctoral fellows, travel expenses, running costs)

Funding categorie(s): Agropolis Fondation doctoral and post-doctoral fellowships

Project duration: 2 January 2008 – 31 december 2010

Keywords: *Phytophthora* – cocoa- resistance – genetics – genomics – QTL

Year of CfP: 2007

Project No 07035

Project title: International Thematic School: "Agrobiodiversity: people and plants. Tools and analytical methods"
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Unit managing the project: DIADE (Diversity, Adaptation and development of Plants) (IRD, UMII)

Project leader: Jean-Louis Pham (pham(a)ird.fr)

Countries involved in the project: Marocco, Canada, Brazil

Research units from the Foundation's scientific network involved: AGAP, GREEN, RPB

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*), STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*), STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Objectives:

Farming systems in the centres of diversity of cultivated plants—mainly in countries in the South—are still based on broad genetic diversity generated since domestication by farmers' know-how in terms of breeding varieties, and maintained for generations by seed management practices.

It is necessary to conserve this diversity *in situ* because not all germplasm resources can be conserved *ex situ* in gene banks and the latter cannot maintain evolutionary processes. The importance of local human populations for the conservation of agrobiodiversity and of access for small farmers in the South to genetic resources have been highlighted by important international conventions (Convention on Biological Diversity, The Global Plan of Action for The Conservation and Sustainable Utilization of Plant Genetic Resources) to promote the development of *in situ* agrobiodiversity conservation strategies.

In comparison with the conservation and study of *ex situ* collections and with conventional varietal improvement, *in situ* conservation does not benefit from the same structuring effort made by the international community in terms of research, implementation and training. The comparatively recent emergence of this approach, its naturally decentralised nature and the fact that it is set intrinsically in open and hence complex environments all contribute to explaining this.

However, there is a strong demand for training by professionals (scientists, NGOs and decision-makers) in the South who are involved for reasons of interest or political necessity in the conservation and use of the *in situ* diversity of phylogenetic resources. Unfortunately, opportunity for training is seriously lacking (courses, written and web material). Although there is training (at Wageningen for example) on the general and political aspects of the *in situ* conservation of cultivated plants, nothing is to be found on recent tools and methods adapted to the study of agrobiodiversity or on the ways of combining these methods in order to develop multidisciplinary approaches.

The project has a twin aim:

- development of the availability of training in the multidisciplinary study of the agrobiodiversity of cultivated plants in ecosystems in the South with a view to sustained conservation and use;
- training students and professionals in the South in methods and tools for the multidisciplinary analysis of diversity at various levels (plants, agrosystems, practices), to learn the limits and to set their projects in the complex scientific and political context of the conservation and use of biodiversity.

An international multidisciplinary theme school on the analysis of the diversity of cultivated plants and associated farming practices in agrosystems has been organised for doctoral students, researchers and other professionals in the South. This was the occasion for defining and producing the content and teaching material needed to repeat this school at other times and places.

Total Agropolis Fondation funding: € 83,200 (short term contract, travel expenses, accomodation costs, conference room rental fee, equipment costs)

Funding categorie(s): Agropolis Fondation support award for international training courses

Project duration: December 1 2007 – June 30 2011

Keywords: agrobiodiversity – *in situ* conservation – genetic resources – formation – training course

Year of CfP: 2007

Project No: 07036 Completed

Project title: Learning, Producing and Sharing Workshop (*Apprentissage, Production et Partage d'Innovations (Atelier APPRI)*): what tools can be used to strengthen capacity, accompanying measures, collective construction and the sustainable implementation of innovations in dry rural zones in Africa?

Unit managing the project: AGAP (Genetic improvement and Plant adaptation) (CIRAD, INRA, Montpellier SupAgro)

Project leader: Danièle Clavel (clavel(a)cirad.fr)

Countries involved in the project: Burkina Faso, Senegal, Brazil

Research units from the Foundation's scientific network involved: Innovation LSTM, SYSTEM

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*), STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*), STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Objectives:

The FAO 2006 annual report highlights the fact that sub-Saharan Africa pays the heaviest tribute to hunger. The number of poorly fed people had increased from 169 to 206 million in 10 years, with a concentration of hunger in rural zones with the stagnation of farming and especially food crops.

The classification arid to dry sub-humid applies to 45% of the area of Africa. The region is particularly strongly affected by climate changes and recurrent drought. In spite of these difficult conditions, the small farms that form more than 90% of holdings are still the pivot of the economies of most African countries as they provide nearly 60% of jobs and GNP.

We propose to organise a colloquy to consider the conditions and actions that would improve the pertinence and impact of agricultural innovations in the context of the sustainability of the kinds of small farming observed in Africa. The colloquy will be held in French-speaking Sahelian Africa and will be aimed at identifying the need for research and the subjects to be addressed by research in multi-stakeholder participation.

The main expected results are:

- better stakeholder awareness of participatory approaches for the improvement of the results of African agriculture in dry zones;
- thanks to contacts with the farming universities in the Nordeste in Brazil, building a conceptual framework for a multi-stakeholder discussion able to formulate, design, monitor and evaluate agricultural projects in these zones.

Action carried-out and results obtained:

The APPRI2008 workshop was a CIRAD initiative, in collaboration with IRD, INERA and CPF (*Confédération Paysanne du Faso*) with financial support from *Agropolis Fondation*, CTA and the French Embassy. It was attended by 50 participants from Burkina, Cameroon, Ethiopia, Ghana, Guinea, Mali, Niger, Senegal, Sudan, Tanzania, Kenya and Brazil. They came from professional farmer organizations, NGOs, and research and training organizations operating in the drylands of Africa.

The main aim was to analyse conditions for implementing alternative action-research practices in partnership for development, taking into account the difficulties of "official" research and of the rural world, faced with the major challenges of sustainable development in the South. One originality of APPRI2008 was to compare experiences in the rural zones of Africa, presented during the workshop, with those of the UNICAMPO Peasants' University set up 10 years ago in the Brazilian Nordeste, a semi-arid region where farms exhibit some major similarities with those in the drylands of Africa.

The "**Peasants' University**" concept was unanimously chosen as a place to unify partnership initiatives bringing together research, rural development officers, farmer organizations and producer groups, and rural communities and municipalities. These **Peasants' Universities** will be places of learning where a common vision is shared for implementing development and environmental improvement activities, particularly intended for small family farms.

The APPRI2008 group unanimously accepted that technical and institutional innovation in partnership is paramount. It needs to be co-constructed from local know-how and scientific and technical knowledge. Information and communication between all those involved in development needs to be revised and strengthened, in order to be more interactive and more efficient. The aim is not only to improve agricultural production but also to contribute to cultural recognition and participate in the social and economic transformation of rural communities.

The action to be promoted through these universities is intended to enable rural African communities to take on board innovations, notably through:

- the construction of **exchange networks based on a core of APPRI2008 resource-persons made up from the stakeholders present**,
- strengthening of capacities and training for all innovation stakeholders, including researchers,
- co-learning for researchers, developers, farmers and rural populations,
- drawing up of the content and dissemination of appropriate scientific documentation and information that is decentralized and combined with local know-how.

The Peasant's University is construed as a social innovation, a place for the convergence of know-how, using an "**innovation caravan**" as the central strategy for mobilizing local, national and international solidarity, exchanges and capitalization of know-how. The tools to be developed by the caravan will notably be:

- identification of active and operational rural groups,
- assistance in formulating and expressing needs, and gathering proposals,
- collective drafting of a charter listing the principles for implementing concrete projects,
- discussions about projects, difficulties encountered and strategies adopted locally,
- thoughts about project monitoring-evaluation systems,
- dialogue with local, traditional, municipal and national authorities,
- proposed actions for exchanges, adding value and education: exhibitions, forums, itinerant, open and remote training.

Total Agropolis Fondation funding: € 40,000 (communication costs, travel expenses, accommodation costs, conference room rental fee)

Funding categorie(s): Agropolis Fondation small grants (support for the organisation of high-level scientific events (conferences, seminars))

Project duration: January 2 2008 – December 31 2008

Keywords: dry lands – arid lands – conference – climate changes

Year of CfP: 2007

Project No: 07042 Completed

Project title: The varietal diversification process in fig and olive in Morocco: an ethnobiological and genetic interdisciplinary approach.

Unit managing the project: AGAP (Genetic improvement and Plant adaptation, CIRAD, INRA, Montpellier SupAgro)

Project leader: Françoise Dosba (dosbaf@supagro.inra.fr)

Country involved in the project: Morocco

Research units from the Foundation's scientific network involved: DIADE

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*), STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Objectives:

The aim of the project is the identification of the varietal diversification processes in two Mediterranean fruit species with strong emblematic, cultural, social and economic value—fig and olive. Cultivation of the two species is very ancient around the Mediterranean but their situation is very contrasted in Morocco as regards genetic structure, functions and uses. This unique, paradoxical feature leads us to questioning firstly the biological and genetic foundations and secondly the historical, social and cultural bases that have resulted in this contrasted situation. We address the question using a combined genetic and ethnobiological interdisciplinary approach. A common field for the work undertaken in the Rif region in Morocco will make a solid contribution to enriching the combined use of the two disciplines.

Two initial actions are planned for fig to establish solid foundations for knowledge:

- verification of the hypothesis of the existence in Morocco of multiple centres of local domestication of fig using a genetic approach
- identification of the social and cultural factors in the Rif fig diversification process.

Action carried-out and results obtained:

This research project was focused mainly on gaining insight into and identifying the key biological and social factors that determine the variety diversification process in two emblematic fruit tree species with high socioeconomic potential—fig and olive. We investigated this issue essentially with respect to fig trees through an interdisciplinary ethnobiological–genetic approach.

The thesis research of H. Achtak involved surveys and sampling of local fig varieties and spontaneous populations (seedling) in six eco-geographic zones in northern, central and southern Morocco where traditional agroecosystems prevail. These fig samples were analysed with microsatellite markers and a population genetics approach. The thesis research of Y. Hmimsa involved surveys in 189 villages in the Rif region of northern Morocco, which is a mountainous area inhabited by three distinct sociocultural groups (Jbala, Zenetes and Ghomara), in order to record fig variety names and their pomological characteristics. Semi-structured interviews and ethnobiological surveys were conducted in the village of Talandaoued to assess the classification of fig varieties in that region.

The ethnobiological analysis revealed that fig is a key element in traditional mountain agroecosystems such as those found in northern Morocco. The varietal diversity is the result of farmers' practices associated with the social organization, family choices and plant exchange

conditions. Fig varieties are exchanged between neighbouring areas and seldom over long distances. We also examined the role of different types of management of spontaneous figs within cultivated areas and the classifications of these seedlings. We thus identified a social and technical varietal selection process that is under way in northern Morocco (thesis of Y. Hmimsa).

The genetic analysis revealed that domestication of spontaneous fig trees is a highly localised process (within geographical zones such as the Rif in northern Morocco and the oases in the south). There is high genetic proximity between spontaneous fig seedlings and local varieties within each region. These close genetic relationships could also be partly explained by gene flow between varieties and spontaneous figs, and also by farmers' practices that were highlighted by the ethnobiological studies, including caprification and management of seedlings and vegetatively propagated trees within cultivated fields (thesis of H. Ahtak).

In light of the interdisciplinary ethnobiological–genetic study findings in this project, we propose a scenario explaining the domestication and diversification processes under way, which would warrant further study, especially in relation to in situ conservation. In fig, varietal diversification is the result of farmers' selection of local spontaneous figs, while the combined effects of biological traits of the tree and socioeconomic factors are also involved. In olive, ongoing research (thesis of H. Haouane) has indicated that diversification may be the result of primary domestication and secondary diversification facilitated by the combined presence of vegetatively propagated trees and spontaneous figs within cultivated fields. This shows the dynamic role of farmers' practices in the varietal diversification process.

Publications:

H Ahtak, A Oukabli, M Ater, S SantoniJ. F Kjellberg, B Khadari (2009) Microsatellite Markers as Reliable Tools for Fig Cultivar Identification , AMER. SOC. HORT. SCI. 134(6):624–631. 2009.

H Ahtak, A Oukabli, M Ater, S SantoniJ. F Kjellberg, B Khadari (2010) Traditional agroecosystems as conservatories and incubators of cultivated plant varietal diversity: the case of fig (*Ficus carica* L.) in Morocco, BMC Plant Biology, 10:28

Prospects for the future:

On the basis of several projects and collaborations (FruitMed 901-007, GDR Mosaique 3353, collaboration with ICARDA), we are pursuing our research by conducting an in-depth study on the role of clonally propagated trees and spontaneous figs in the diversification of Mediterranean fruit trees. In addition, we will assess the roles of public policies and new stakeholders such as nursery growers in the configuration of tree agrodiversity in the Mediterranean region. Following the discussions currently under way on the research organization in the Mediterranean Basin, we plan to develop a large-scale ANR project on diversification processes in relation to in situ conservation and the evolution of traditional agroecosystems.

Total Agropolis Fondation funding: € 75,980 (salary for two PhD students, travel expenses, running costs)

Funding categorie(s): Agropolis Fondation doctoral fellowship

Project duration: January 2 2008 – December 31 2010

Keywords: crops – olive tree – fig tree – Méditerranée – diversity

Year of CfP: 2007

Project No: 07044 Completed

Project title: Capitalization and capacity building on method to assess and develop agroforestry innovation in humid tropics (Africa and Mesoamerica)

Unit managing the project: Innovation (CIRAD, INRA, SupAgro)

Project leader: Nicole Sibelet (nicole.sibelet(a)cirad.fr)

Countries involved in the project: Madagascar, Kenya, Uganda, Guinea, Cameroon, Ghana.

Research units from the Foundation's scientific network involved: System

Subthematic axes: STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*), STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Objectives:

Even if agroforestry is a common practice for most of the farmers in the world, it was only in the late 1970's that it was recognized as a scientific issue. Since then, the scientific interest on agroforestry has increased, especially in the 1990's when the effects of pollution, loss of biodiversity, greenhouse gas emission, etc. started to be more pronounced and felt in industrialized countries.

Transdisciplinarity studies are necessary to analyze the complexity of agroforestry, which provides products and services of different types (social, economic and environmental). As new tools become available (e.g., stem flow gauges, isotope methods, sonic anemometers, etc), studies at the plot scale, i.e., on, above and below ground competition and facilitation relations, have produced useful results for evaluation and design.

In socio-anthropological science, crossing kinship and land tenure theories now allows for the analysis of stakes related to the access rights on agroforestry products. Modeling techniques useful for the synthesis of results from both transdisciplinary and socio-anthropological science as well as the development of decision making tools are still scarce.

The objective of this project is to synthesize information on participatory methods for evaluation and design of agroforestry systems (AFS) and contribute to the improvement of conceptual frameworks by including francophone experience of different research units from the biophysical, agronomic, and socio-economic sciences.

This includes combining experiences on the following

- Farmers' knowledge appraisal methods
- Space and temporal characterization of AFS dynamics and their determinants
- Conceptual models for system approach (both to synthesis, compare and facilitate exchange between farmers and experts/scientists knowledge)
- Different models (biophysical, economic, process- based, etc.)
- Evaluation of environmental services, including payments schemes and taxes, if possible.

Action carried-out and results obtained:

Hosting postPhD for 12 months for the development of research on the dynamics of Agroforestry systems

Thematic School on Social sciences Methods of applied to agroforestry

Two won projects EU 2008 FUNICTREE and ANR 2010 INTSEN& FIX

2 publications in reviews with impact factors

Missions reports. Research reports (1 produced by the School participants in French and in English + 1 produced by 2 teachers and 2 participants) + Oral feed-back to local stakeholders + evaluations + press release

Publications:

Chloe N. Marie, Nicole Sibelet, Michel Dulcire, Minah Rafalimaro, Pascal Danthu, Stephanie M. Carriere (2009) Taking into account local practices and indigenous knowledge in an emergency conservation context in Madagascar. *Biodivers Conserv*, Volume 18, Number 10, 2759-2777

Aboubacar Camara, Patrick Dugué, Jean-Paul Cheylan, Jean-Marie Kalms (2009) De la forêt naturelle aux agro-forêts en Guinée forestière. *Cah Agric*, vol. 18, n° 5

Prospects for the future:

1) An elearning on social sciences Methods applied to agroforestry is built with funds of UVED/CIRAD and IAMM based on 2009 Thematic School. A pilot version of two modules is on test. Developments are scheduled: translations in English and Spanish, adaptations and creations; new case studies and construction of other modules this elearning could be used in particular as bases of methodological support in multidisciplinary projects and pluripartnerships.

2) From January 2011, CIRAD and CATIE will build a duo through Nicole Sibelet and Isabel Gutiérrez to strengthen sociology on environmental issues. Both are specialised in Stakeholders' perceptions, local knowledge, practices and strategies facing environmental risks applied to agroforestry systems.

Total Agropolis Fondation funding: € 148,000 (Post-doctoral fellowship, travel expenses, transportation)

Funding categorie(s): Agropolis Fondation post-doctoral fellowship, Agropolis Fondation support award for international training courses, Agropolis Fondation small grants (support to prepare applications for national and international calls for proposal, e.g. ANR and EU FPs)

Project duration: 2 January 2008 – 30 November 2010

Keywords: agroforestry – innovation – international thematic school

Year of CfP: 2007

Project No: 07045 Completed

Project title: International symposium on 'Innovation and sustainable development', 2010

Unit managing the project: INNOVATION (Innovation and development in agriculture and the agrifood sector) (INRA, CIRAD, SupAgro)

Project leader: Hubert Devautour (hubert.devautour(a)cirad.fr)

Country involved in the project: Netherlands

Research units from the Foundation's scientific network involved: DIADE, GREEN, LAMETA, MOISA

Subthematic axes: STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*), STDI-2 (Socio-Technical Dynamics of Innovation 2: *Agrifood innovations, food and non-food use of plant crops*), STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Objectives:

'Innovation' is a research theme addressed by different scientific disciplines, often with the use of several definitions and methods of analysis. However, most of the questions and work conducted today are focused on the conditions of innovation, procedures for the involvement of stakeholders in innovation processes, the effects of innovations in sustainable development and the possible forms of public accompaniment. Agriculture and the agrifood sector have an important position in this research work because of a new context marked in particular by the upsurge of quality and its many definitions, the evolution of relations between science and society and the appearance of the sustainable development paradigm.

Innovation processes in agriculture and the agrifood industry are the subject of different forms of interdisciplinary approaches for reasons of their technical, sociological and economic dimensions: bid invitations and research projects, international conferences and seminars, books or issues of journals. These multidisciplinary approaches to innovation make it possible to question the coexistence of different innovation paradigms, to re-examine the targets of the stakeholders who innovate and to engage in more rigorous analysis of the effects of the development (without any connotation of positive or negative value) of these processes.

The objectives of this international symposium in Montpellier in 2010 are as follows:

- to set Montpellier agricultural research facilities in international discussions—from the angles of both science and society— of the study of innovation processes, the position and role of agricultural research in these processes and the results and effects of these processes with regard to sustainable development.
- to set a framework for interdisciplinary discussion centred on new approaches to innovation (participatory research, interactions between scientific knowledge and hands-on knowledge for example) and development (original development practices and pathways raising new questions for the research sector)

Action carried-out and results obtained:

Following the meetings of the scientific committee, the following programme has been suggested:

Montpellier, France – Corum, June 28 – July 1, 2010

Facing the crisis and growing uncertainties, can science and societies reinvent agricultural and food systems to achieve sustainability?

Come exchange with researchers and actors from the whole world, around the evolution of innovation systems, to build together new perspectives for scientific agendas, and help renew actions and policies to better achieve sustainability.

Recognized personalities will present their views during key note lectures:

- Andy Hall (United Nations University) : Questions put at stake for innovation systems today
- Papa Seck (Africa Rice, ex-ADRAO): How to conceive innovating agricultural policies in Africa to feed this continent in a sustainable and sustained way?
- Juliana Santilli (Public Ministry, Brazil) : Innovating to enhance agrobiodiversity, recognize collective intellectual rights and enable more social equity
- Lawrence Busch (Michigan State University) : Acting sustainably: Governance through standards in a times of « corporate science »
- Robert Watson (DEFRA - University of East Anglia) : Renewing agricultural research

Parallel sessions will enable to discuss specific issues, by exchanging experiences with actors from the whole world

350 papers will be presented. Come discuss innovations for agroecology and ecological intensification, producer inclusion and social equity, adaptation strategies facing change, social construction of standards, participatory research, etc.

During round tables, key stakeholders will share their practices and reflections on the challenges research is currently facing.

Parallel round tables:

- Innovation systems in practice: challenges and perspectives. Organised with the World Bank
- Innovation policies: case of the Mediterranean region. Organised with OECD, IFAD and ArimNet
- Regional dynamics of innovation. Organised in partnership with the Languedoc-Roussillon region and the PSDR project (Pour et Sur le Développement Régional – On and For Regional Development).

Final round table : Perspectives to reinforce links between research and action in innovation systems

Prospects for the future:

The Symposium will be held from June 28 to July 1.

Expected diffusion:

Papers will be published on a CD-Rom which will be distributed during the conference and then posted on-line as the conference proceedings. For each session, agreements will be engaged to publish special issues in international journals (English-, French- and Spanish-language journals).

A special book will be published to present a global view of issues dealing with innovation and sustainable development, including key note lectures and the syntheses of round tables and parallel workshops.

We will invite representatives of the general press as well as of professional reviews dealing with political issues or with advisory and support services. The results of the symposium will also be used in training workshops and research schools to feed reflection on research methods and practices in Northern and Southern countries.

Total Agropolis Fondation funding: € 30,000 (3 months contract for a librarian, travel expenses, running costs, organisation of the meeting)

Funding categorie(s): Agropolis Fondation small grants (support for the organisation of high-level scientific events (conferences, seminars))

Project duration: December 1 2007 – December 30 2010

Keywords: innovation – sustainable development – agronomy – social sciences - symposium

Year of CfP: 2007

Project No: 07047 Completed

Project title: Leaf growth and soil water deficit in <i>A. thaliana</i> and apple tree: The 3 dimensions

Unit managing the project: LEPSE (Ecophysiology of Plants under Environmental Stresses) (Inra, SupAgro)

Project leader: Christine Granier (granier(a)supagro.inra.fr)

Country involved in the project: UK

Research units from the Foundation's scientific network involved: AGAP

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*)

Objectives:

Total leaf biomass in a plant is an integration of variables depending on elementary processes such as leaf production, duration and rate of expansion of each individual leaf, leaf thickness, cell production and cell expansion. As a first step to a modelling approach of whole plant leaf growth, it is necessary to elucidate how the different leaf growth variables are related to one another. Until now, the causal or functional links between underlying leaf growth variables have not been clearly identified. In addition, the scale and the tissue at which the control of growth occurs, is not clearly established.

The contribution of the different processes potentially involved in the responses of *A. thaliana* leaf growth to environmental stresses (focusing mainly on drought) is currently being evaluated in the LEPSE research unit. An automated phenotyping platform (PHENOPSIS) is set up to grow plants in reproducible environmental conditions, including optimal conditions and well-characterized drought stresses.

Until now, growth was only considered as expansion in area and was broken down further into a set of underlying variables such as leaf expansion rate and duration of leaf expansion, epidermal cell number and size. Reproducible relationships between these variables and micro-meteorological conditions could be established. However, leaves also grow in the third dimension.

The objectives of this project are

- to analyse the relationships between cellular leaf growth variables
- to identify functional links between them
- to evaluate their contribution to the plasticity of leaf growth in response to drought. For this purpose, an ecophysiological approach will be combined with statistical modelling both in apple tree, one of the most economically important tree crops grown worldwide and *A. thaliana*, as a plant model system.

Protocols will be established to reproducibly analyse cell area, cell number and cell volume in the different leaf tissue layers in both species. Automatic procedures for image analysis will be developed to increase the throughput of the experiments. Then, leaf growth will be altered both via genetic and environmental perturbation, taking advantage of the large collection of genetic backgrounds available in the two groups (*A. thaliana* and apple tree) and the capacity to impose reproducible drought treatments in LEPSE. Throughout the project, a statistical modelling approach to analyse and interpret the mass of data collected at different scales will be developed.

Analysis of interactions between leaf area plasticity and leaf thickness is lacking in both studies (*A. thaliana* and apple tree). Combining the expertise of different partners in dicotyledonous leaf growth and in statistical and functional modelling, will allow the development of a model leaf growth in 3-D.

Action carried-out and results obtained:

Leaf growth processes can be evaluated at different organisational levels, such as cells, the individual leaf and the whole plant. On the cell and leaf level, most studies have been limited to the leaf surface with data collected on leaf surface area and the number and surface area of epidermal cells. However, leaf sub-epidermal tissues, the palisade and spongy mesophyll, contain the main actors in photosynthesis and their cellular organisation may affect leaf transpiration and the accumulation of photosynthates, which further influences whole plant growth. As studies into the three dimensional development of leaves are rare, the interaction between the different cell layers (epidermal and sub-epidermal) during growth is largely unknown and the effects of particular environmental stresses, such as soil water deficit, on internal leaf tissues have not been thoroughly investigated.

The aim of the present project was to develop a procedure for the three dimensional imaging and analysis of leaves to obtain leaf growth variables specific to internal leaf tissues. The further aim was to characterize leaf growth in three dimensions, under well-watered conditions and soil water deficit, for *Arabidopsis thaliana* and apple, two dicots with a largely differing leaf cellular organisation.

The development of the procedure for three dimensional imaging and analysis of leaves was successful and gave consistently high-quality images for both *A. thaliana* and apple [Plant Methods, 2010, 6: 17]. The procedure consisted of a leaf sample preparation phase, an imaging phase and finally an image analysis protocol. Leaf sample preparation included leaf fixation and conservation to allow for the typically large quantities of samples issued from phenotyping platforms (Phenopsis, Lepse, INRA Montpellier) [<http://bioweb.supagro.inra.fr/phenopsis/>], and efficient sample clearing and coloration for successful tissue penetration and image acquisition. Three-dimensional imaging was performed on the multiphoton microscope (Zeiss LSM 510 Meta NLO equipped with a Chameleon femtosecond laser) of the Montpellier RIO Imaging platform and provided high resolution images of the entire thickness of leaves, enabling the three dimensional visualisation and analysis of internal leaf tissues. Finally, image analysis macros were developed in the open source software ImageJ [<http://rsb.info.nih.gov/ij/>] which allowed annotated and structured storage of image data and variables measured on images, and standardized, semi-automated and assisted measurement of leaf growth variables, including leaf surface area and thickness, tissue proportions, cell densities and cell volumes in the leaf epidermis and mesophyll. Three dimensional visualisations of leaf images and leaf structural models was performed in the MedINRIA ImageViewer software (Asclepios Research project, INRIA Sophia Antipolis) [<http://www-sop.inria.fr/asclepios/>].

The procedure was applied in a study of leaf growth, from emergence until maturity, in *A. thaliana* and apple and provided data on the longitudinal (tip-to-base) gradient in leaf development and the transversal gradient between leaf tissues, including data on epidermal and mesophyll proportions, cell densities and cell volumes over time. For *A. thaliana* the study was extended to the characterization of the effects of soil water deficit on cell proliferation and differentiation in the epidermis and mesophyll of a range of genotypes, including mutants affected in leaf transpiration.

Publications:

Wuyts N, Palauqui JC, Conejero G, Verdeil JL, Granier C and Massonnet C (2010) High-contrast three-dimensional imaging of the *Arabidopsis* leaf enables the analysis of cell dimensions in the epidermis and mesophyll. Plant Methods, 6-17

Fabre J, Dauzat M, Nègre V, Wuyts N, Tireau A, Gennari E, Neveu P, Tisné S, Massonnet C, Hummel I & Granier C (2011) PHENOPSIS DB: an Information System for *Arabidopsis thaliana* phenotypic data in an environmental context. BMC Plant Biology 11:77.

Prospects for the future:

An efficient protocol for three dimensional imaging was developed and published and allows for in depth studies on cellular organisation in developing leaves from initiation until senescence of

Arabidopsis thaliana, apple and other species. It offers the potential to extend our current knowledge of leaf growth processes, under influence of both genotype and environment, to the inner cell layers of leaves and provide the necessary data for the establishment of a complete cellular model of leaf growth which can be integrated into a whole plant growth model.

Groups involved in this project are looking for further financial supports to analyse further data and images produced during the project with still the objective to establish a 3D model of leaf development at the cellular level.

Total Agropolis Fondation funding: € 117,943 (salary for a post-doctoral fellow, travel expenses, running costs)

Funding categorie(s): Agropolis Fondation post-doctoral fellowship

Project duration: 15 March 2008 – 1 December 2010

Keywords: *Arabidopsis* – apple tree – leaf growth – modelling – drought – stress

Year of CfP: 2007

Project No: 07049 Completed

Project title: The 'integrative biology' community in Montpellier - Perpignan – Avignon - 1st Languedoc Roussillon – Catalonia meeting on Integrative Plant Biology
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Unit managing the project: LEPSE (Ecophysiology of Plants under Environmental Stresses) (INRA, Montpellier SupAgro)

Project leader: François Tardieu (tardieu(a)supagro.inra.fr)

Country involved in the project: Spain

Research units from the Foundation's scientific network involved: LGDP

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*)

Objectives:

In Languedoc Roussillon and Catalonia, a substantial scientific community has been working for many years on the development and adaptation of plants to the environment. There have always been links between our two communities, resulting in particular in an Associated European Laboratory that has linked for 12 years the LGDP (UMR CNRS 5096) and the CSIC centre in Barcelona. To focus on coordination and grouping, the scientific communities in the sector in each region have centred themselves on IFR 127 DAPHNE on the one hand and the consortium CSIC-IRTA, a new institute managed by P. Puigdomenech and uniting CSIC, IRTA and Barcelona University scientists on the other. We therefore have an opportunity to set up a European scale trans-regional centre devoted to integrative plant biology.

The aim of this project was to bring together for the first time all the teams of IFR 127 DAPHNE and the consortium CSIC-IRTA-UB within the framework of the 1st Languedoc Roussillon – Catalonia meeting on Integrative Plant Biology. It was organised by Manuel Echeverria (Director of LGDP UMR 5096) and Pep Casacuberta (Consortium-CSIC). It was attended by some 150 IFR and Consortium research scientists, lecturer/researchers and students. It was held on 3 and 4 December 2007 at Banyuls-sur-mer (halfway between Montpellier and Barcelona). A series of talks by researchers and leading teams from the various IFR and Consortium laboratories made it possible to draw an accurate picture affording a clear view of the objectives and the work performed by our two communities.

This should make it possible to generate dynamics of interaction between our communities with the aim of developing joint projects in integrative biology that are of fundamental interest for our trans-Pyrenean region and that also carry weight at the European level.

Action carried-out and results obtained:

The 1st Languedoc Roussillon - Catalonia Meeting in Integrative Plant Biology focused on the topic "Molecular and genetic aspects of plant development and their adaptation to stresses". The event, held on 3-4 December 2007 at Arago Laboratory in Banyuls sur Mer (France), was organized to facilitate contact and exchange between the research community in Languedoc Roussillon and Catalonia as well as to contribute to the emergence of a strong European pole in this field.

A total of 110 researchers and students from Barcelona, Cabriils, Perpignan, Montpellier and Avignon participated in this meeting where about 20 presentations were made illustrating the some of the most outstanding works of the research teams involved. The event facilitated the establishment of contacts and linkages between the two scientific communities which should be reinforced in the future and which may give rise to future collaborations, projects and exchange of students or PhDs.

Prospects for the future:

The 1st meeting has been very much appreciated by the participants, and has fully achieved its objectives. We have thus decided, with the support of the scientific community, to pursue this event through the organization of the 2nd Meeting in Spain.

Total Agropolis Fondation funding: € 8,077 (travel expenses, conference room rental fee, catering costs)

Funding categorie(s): Agropolis Fondation small grants (support for the organisation of high-level scientific events (conferences, seminars))

Project duration: October 26 2007 – March 1 2008

Keywords: integrative biology – symposium – interdisciplinarity

Year of CfP: 2007

Project No: 07051 Completed

Project title: 13th World Water Congress – Montpellier 1 – 4 September 2008
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Unit managing the project: LISAH (Laboratory for soils, agrisystems, hydrosystems interaction studies) (INRA, IRD, Montpellier SupAgro)

Project leader: Marc Voltz (voltz(a)supagro.inra.fr)

Countries involved in the project: Australia, Tunisia

Research units from the Foundation's scientific network involved: AGAP, DIADE, ECO&SOLS, EMMAH, GREEN, INNOVATION, LEPSE, PSH, SYSTEM.

Subthematic axes: IPB-1 (Integrative Plant Biology 1: *Genetics and genomics, plant breeding, ecophysiology*), IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*), STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*), STDI-2 (Socio-Technical Dynamics of Innovation 2: *Agri-food innovations, food and non-food use of plant crops*), STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Objectives:

The aim of the 13th World Water Congress, held under the aegis of the International Water Resource Association (IWRA) at the Corum in Montpellier from 1 to 4 September 2008 was to make a contribution to knowledge on the impact of global climate change on water resources and to improve awareness by civil societies. It was a unique opportunity to stimulate discussion between public and private partners, between users and decision makers and between developing, emerging and developed countries. The Congress organised numerous high-level lectures, ordinary scientific sessions, special sessions, poster sessions, technical displays (equipment, books and journals) and technical visits.

The project supported the organisation of the congress. Agropolis Fondation made a contribution to the overall congress budget and to the organisation of a special session on themes of interest to the scientific units backed by the Fondation.

The main theme chosen for the Montpellier congress was 'Global changes and water resources: confronting expanding and diversifying pressures'. It was open to all water stakeholders: scientists, local authorities, industry, associations, international organisations, etc.

Special operations brought the theme to the general public and young people: an exhibition called 'Water for Everyone' (*Cité des Sciences et de l'Industrie*), lectures, drawings and painting, shows, a festival of short films, etc.

Action carried-out and results obtained:

To provide an overview of the most advanced research programs in agricultural sciences that attempt to answer the previous issues and to stimulate discussion on the most promising perspectives a special session was organised with the support of Agropolis Fondation during the World Water Congress that took place in Montpellier in September 2008. The congress has attracted specialists in water sciences from around the world. The research topics that were addressed in the special session concerned plant breeding, cropping system innovation and land management innovation and optimization.

The session consisted of 5 keynote talks followed by a general discussion introduced by three discussants.

Keynote talks

1. Breeding crops for drought: How to develop water-efficient and drought tolerant cultivars. Perspectives and limits. Speaker: François Tardieu, INRA, UMR LEPSE, Montpellier
2. Designing crops for improved water productivity – Modelling G*M*E. Speaker: Graeme HAMMER, University of Queensland, Australia.
3. Optimization of cropping systems for sustainable water management in rainfed and irrigated systems: Integrative modelling at field and farm levels. Speakers : Jacques-Eric Bergez, INRA UMR AGIR, Toulouse, France, François Affholder CIRAD, Montpellier, France
4. Water harvesting techniques at the field and catchment level: State of art and new research challenges. Speakers: Jean Albergel, IRD, UMR LISAH, Nairobi, Kenya and Nathalie Gomes, IRD, Kenya
5. Participative modelling of agricultural water demand at regional scale: Aan example in Central Tunisia. Speakers : M. Le Bars, IRD, UMR G-EAU, Montpellier, France); Ph. Le Grusse, CIHEAM-IAMM, UMR G-EAU, Montpellier, France

Open discussion

Discussants: Australia: Graeme HAMMER, University of Queensland - France, Bernard Itier, INRA, Grignon - Tunisia: Netij Ben Mechlia, INAT, Tunis

Moderators : Jacques Wery, SupAgro, UMR System, Montpellier, France - Thierry Simonneau, INRA, UMR LEPSE, Montpellier, France

In contrast to the talks which focused each on the issues and perspectives of given research approaches for improving water use and management approaches in cropping systems, the general discussion aimed at comparing and evaluating the respective merits and potentials of the various research approaches in different regional contexts. To this aim three discussants from Australia, France and Tunisia introduced the discussion by presenting which are the main issues related to water availability and water efficiency for crop production in their country and what are the current research perspectives that are considered the most promising.

The session has allowed to identify some key research issues from which future collaboration of agronomists, hydrologists and economists can be developed:

- 1) Transition from component to system design. Soil and plant and water studies should converge with integrated studies to look for optimal combinations of GenotypeX Crop Management X Water Management maximising production and environmental services under specific water deficit scenarios (combining climate and soils).
- 2) Transition from Sectoral/Scale specific studies to Integrated Assessment across scales in order to design sustainable water management systems in agricultural regions. Among the issues discussed were the following:
 - comparison of strategies (genetics, crop successions, water harvesting...) for water saving, water use efficiency or water productivity
 - multicriteria assessment of these solutions at relevant scales
 - design of systems providing resilience through crop diversity and flexibility in water management
 - design of systems based on risk assessment and climate forecasting
- 3) Role and methods of models adapted to these objectives with emphasis on the following aspects:
 - Integrated modelling across scales and sustainability dimensions and thereby across disciplines
 - Targetted models for specific uses and users

- Organisation of data collection and sharing among disciplines

Prospects for the future:

Multidisciplinary projects that aim to follow and implement the main conclusions of the special session in terms of research needs may be prepared in the future. The Agropolis Fondation units that supported the organisation of this special session as well as the foreign invited speakers are potential partners of such projects. This initiative may be integrated within the framework of a larger research program that aims to study the changes of Mediterranean continental ecosystems under climatic and anthropic pressure (SICMED) which is currently being set up by INRA, IRD and INSU.

Total Agropolis Fondation funding: € 12,632 (registration fees, travel expenses and accommodation costs for 10 speakers)

Funding categorie(s): Agropolis Fondation small grants (support for the organisation of high-level scientific events (conferences, seminars))

Project duration: January 2 2008 – November 30 2008

Keywords: water – symposium – conference – climate changes

Year of CfP: 2007

Project No: 07054 Completed

Project title: Digital analysis of the stability of a forest slope with integration of the space-time dynamics of the stand
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Unit managing the project: AMAP (botany and computational plant architecture) (CIRAD, CNRS, INRA, IRD, UMII)

Project leader: Thierry Fourcaud (thierry.fourcaud(a)cirad.fr)

Country involved in the project: Togo

Research units from the Foundation's scientific network involved: Eco&Sols, System

Subthematic axes: STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*)

Objectives:

In many parts of the world, increased precipitation resulting from climate changes intensifies landslide risks considerably. In southern countries, these risks are aggravated by the strong pressure exerted on land by local farming and development policies. The emergence of questions about the best way of achieving sustainable management of sites exposed to such risks is the subject of a research theme called 'eco-engineering for slope stability'.

Togo is faced with serious landslide problems in the southern part of the Atakora mountain range. Large areas of forest have been cleared since the 1970s for growing coffee, cacao, cotton and food crops. The harvesting of construction timber and firewood and the intensive gathering of plants used in the traditional pharmacopeia have led to the degradation of vegetation, loss of soil fertility, erosion, landslides and the silting of watercourses by the sedimentation of particles resulting from erosion. Togo now faces a major challenge—the restoration and rehabilitation of highland soils. New reforestation, development and sloping land restoration programmes have been initiated for this, supported by the public authorities, NGOs and village associations. The programmes are financed by the International Tropical Timber Organisation. Developing master plans for works requires data on the intensity of soil degradation and the capacity of the different local species to strengthen and conserve slopes. Such data are currently lacking.

The installation of suitable vegetation is an environment-friendly alternative to the structures traditionally used by geotechnicians (netting, geotextiles, etc.). Indeed, the roots improve soil cohesion by their tensile strength and adhesion and friction at the root-soil interface. Furthermore, the vegetation changes the water regime of the slope through various soil/plant interactions. Increased study is being devoted to the contribution of roots to slope stability. However, older models consider vegetation that is spatially homogeneous in planes parallel to the surface of the ground. Such models are not suited to a forest situation in which root distribution is heterogeneous as regards the individual and the slope.

We developed a finite element slope stability model in the laboratory. This analytical tool takes the 3-D structure of a forest stand into account and makes it possible to quantify the contribution of forest tree root systems to the stability of sloping soils, taking the forest structure (density, spatial distribution of species and of their root system) into account. This project is aimed at integrating the space-time aspects of the growth of trees and their roots (by integrating hydrological processes) to appraise the impact of forest management on the strengthening of slopes in the long term.

Action carried-out and results obtained:

This project has set up a battery of digital tools and 2D and 3D models (based on the finite element method, FEM) to analyze in a generic way the influence of vegetation on slope stability. These tools and models take into account the mechanical effects (soil reinforcement by roots) and water (influence of roots on soil hydraulic conductivity and water status of the slope). They have been used in studies conducted in Togo (unpublished results) and on the Loess Plateau in China (results under publication). The actions undertaken concern the following:

Action 1 - Development of a library of tools (under the form of Python scripts) in the computer code Abaqus FEA to model a forest slope and determine its degree of stability. This library consists mainly of: 1 - a generic builder of slope geometry that can set a rectilinear slope (profile, angle, height, ...) and associate its physico-mechanical properties, 2 - a generator which allows to set the geometry and properties of root compartments depending on the species (represented by half-sphere, cylinder or cone; dimensions; associated additional cohesions) and distribute the trees on the slope according to regular (rows of trees) or random patterns; 3 - a manager of analyses, which can run successive simulations to determine the safety factor (cohesion reduction method) and to perform sensitivity studies to different geometrical and mechanical parameters, 4 - a data extractor to determine the safety factor of the slope, the depth of the slip surface and the volume of soil mobilized from simulation results;

Action 2 - Development of a module to read root data (field data, extraction of simulation results the plant architecture simulator AMAPsim, ...) from a domain discretized in space voxels. This tool allows defining continuous maps of additional cohesions (via root densities) that will overlay the original properties of the bare soil at scales of the individual or the slope. This work is still in progress and future results will be published.

Action 3 - Numerical analyses of the impact of various reforestation scenarios on slope stability, taking into account the morphology and size of the root systems, as well as the structure and density of the stand. The model and the results of numerical analyses have been the subject of an article accepted in Ecological Engineering. The results were used to quantify the relative roles of root characteristics and planting patterns on the soil reinforcement.

Action 4 - Consideration of hydrologic factors in the numerical model. Equations of water flow and soil mechanics have been coupled for the analysis of slope stability. The ultimate goal is to take into account the effect of vegetation on the water regime of the slope and its relative impact on the safety factor. This work is being finalized as part of the thesis of Miss Jinnan Ji (co-tutelle Université Montpellier 2, Beijing Forestry University), 2008-2011).

Action 5 - Application to case studies in Togo and China. Field studies were conducted in Togo and on the Loess Plateau in China (Ji Jinnan thesis). They aimed to quantify and spatialize rooting properties (biomass, root number, root area ratio "RAR) in the context of monoculture forests. These data were supplemented by tensile tests conducted in the laboratory and used to calculate the additional cohesion. This information was then integrated into the simulator of slope stability to quantify their contribution to increasing the safety factor. The measurement campaign conducted in China has also identified correlations between root density and soil hydraulic conductivity. These results will help calibrating the hydrological model developed as part of the Jinnan Ji's thesis (see action 5).

Publications:

Adzo Dzifa Kokutse, Alexia Stokes, Nomessi Kuma Kokutse, Kouami Kokou (2010) Which factors most influence heartwood distribution and radial growth in plantation teak? *Ann. For. Sci.* 67 (2010) 407

Ji, J.N., Kokutse, N., Zhang, Z.Q., Fourcaud, T., 2010. Towards a numerical simulation model of short-term impact of forested hillslope stability under rainfall condition. In: Chen, S.-C. (Ed.), *INTERPRAEVENT 2010*. International Research Society INTERPRAEVENT, pp. 446-453.

Prospects for the future:

Action 6 - Establishment of new collaboration projects (Master, PhD thesis, Interuniversity Scientific Cooperation Project AUF) and reinforcing partnerships: Support to this RTRA project and framework for continued works with the University of Lomé (Faculty of Science, Agronomy Faculty,

National School of Engineers), the Beijing Forestry University and the University of Abomey Calavi (Bénin).

Total Agropolis Fondation funding: € 120,000 (salary for a post-doctoral fellow, travel expenses)

Funding categorie(s): Agropolis Fondation post-doctoral fellowship

Project duration: March 1 2008 – July 1 2010

Keywords: simulation – modelling –root – agriculture – climate change – forest – Togo

Year of CfP: 2007

Project No: 07057 Completed

Project title: Preparation of an approach for the Construction of Innovative Agro-ecological Intensification Systems to contribute to more sustainable agriculture (C-SIAD)
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Unit managing the project: INNOVATION (Innovation and development in agriculture and the agrifood sector) (INRA, CIRAD, SupAgro)

Project leader: Bernard Triomphe (bernard.triomphe(a)cirad.fr)

Countries involved in the project: Brazil, Netherlands, Burkina-Faso, Mali, Madagascar, Zimbabwe

Research units from the Foundation's scientific network involved: Green, System

Subthematic axes: STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*), STDI-3 (Socio-Technical Dynamics of Innovation 3: *Innovation processes, social management of innovations*)

Objectives:

In both the North and the South, the combined pressure of changes in society, in the global economic system and the climate means that agriculture is experiencing ecological and economic crises. Locally, these take the form of the degradation of natural resources (soil, water, air and biodiversity) and an increase in the cost of factors of production such as inputs, energy and labour. These crises are felt particularly strongly by the poorest, least-organised farmers, with direct threats to their food security and their capacity to play their role in the reproduction of the ecological services provided by the rural areas and ecosystems of which they are the main trustees. Meanwhile, classic systems of agricultural research and advisory services are often significantly weakened by state withdrawal from the funding of the corresponding institutions and they have difficulty in renewing their paradigms and their intervention modes that are still largely based on those developed and implemented during the Green Revolution after World War 2, while they suffer increasingly from the consequences of growing disciplinary specialisation. Among other things, this evolution is resulting in the fragmentation of agricultural research, the comparative poverty of the innovations proposed in ecological farming and, in spite of the efforts made by supporters of participative research and research-intervention, recurrent difficulties in relations between the research sector and the great diversity of users? This makes the solving of the major challenges involved in the renewing of relations between nature and societies difficult and slow.

The aim of the project is the articulated design and implementation of the measures, approaches and research methods making it possible (1) to characterise the functioning and impact of systemic innovations enhancing ecological intensification and (2) to accompany their emergence in rural societies in the South and the North.

Action carried-out and results obtained:

The PEPITES project (Ecological processes and sociotechnical innovation processes in Conservation Agriculture) was successfully submitted to the ANR SYSTERRA Call for proposal in April 2008. Its objective is to produce knowledge on both ecological and innovation processes and their interactions, to assess and conceive more sustainable cropping and farming systems as well as the set-ups required to accompany the corresponding stakeholders and processes. It focuses on various scales, including the soil, the plant cropping and farming systems, as well as actor networks. It operates in 4 sites: 2 in France (grain cropping systems in Central France, organic agriculture in South-eastern France), and 2 tropical countries (Brazil and Madagascar). Its key partners include research teams from INRA, CIRAD, AgroParisTech, IRD and ISARA-Lyon. It started effectively in January 2009 and will last for four years, under the joint coordination of Stéphane de Tourdonnet (AgroParisTech), Eric Scopel and Bernard Triomphe (CIRAD).

Two CSA (Coordinating and Support action) projects were successfully submitted to the FP7-KBBE Call for Proposal in January 2009. Like PEPITES, the first called CA2Africa (Conservation Agriculture in AFRICA: Analysing and Foreseeing its Impact - Comprehending its Adoption) is coordinated by Marc Corbeels (CIRAD). It focuses on Conservation Agriculture. It will allow to get an in-depth understanding and assessment of different types of modeling approaches, by assessing their main advantages and imitations in the African context. Its objective is to assess and learn jointly from past and on-going CA experiences under which conditions and to what extent does CA strengthen the socio-economic position of landholders in Africa. CA2AFRICA will operate via regional platforms régionales throughout Africa. Its partners include CIRAD and European partners such as ZALF, WUR, and CSIC), CGIAR centres (CIAT-TSBF, CIMMYT, ICARDA) and African partners such as ACT, INERA-Burkina Faso, and INRA-Maroc.

The second FP7 project, called JOLISAA (JOint Learning about Innovation Systems in African Agriculture) is coordinated by Bernard Triomphe (CIRAD). It focuses on multistakeholder innovation systems and processes already tackled in PEPITES, and to a lesser degree in CA2Africa. Its objective is to assess and learn jointly from recent experiences across Africa about how innovation processes involving multiple stakeholders and types of knowledge operate, in order to identify concrete priorities for research, practice and policy for addressing the needs and demands of smallholders and other rural actors. It will operate in 3 sites in Africa (Kenya, Benin et South Africa), in which case studies will be conducted on various types of innovation experiences. Its partners include 4 European institutions (CIRAD, WUR-LEI, ETC, ICRA) and 3 African institutions (University of Pretoria in South Africa, Université Abomey-Calavi in Bénin, KARI in Kenya).

Prospects for the future:

Prospects include mostly the successful implementation of the 3 above projects over the next few years, trying to find synergies among partners, activities and sites whenever possible.

Total Agropolis Fondation funding: € 28,200 (4 months contract, travel expenses, workshop)

Funding categorie(s): Agropolis Fondation small grants (support to prepare applications for national or international calls for proposals (e.g. ANR and EU FPs))

Project duration: January 2 2008 – December 30 2009

Keywords: ecological reinforcement – innovation – agriculture – agronomical research

Year of CfP: 2007

Project No: 07058 Completed

Project title: Understanding emergence of infectious diseases: Linking genomic evolution to the evolution of virulence of a phytovirus during the course of adaptation to its environments

Unit managing the project: BGPI (Biology and Genetics of Plant/Pathogen Interactions) (INRA, CIRAD, SupAgro)

Project leader: Rémy Froissart (remy.froissart(a)supagro.inra.fr)

Research units from the Foundation's scientific network involved: LEPSE, LGDP, PROTEOMIQUE

Subthematic axes: IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*)

Objectives:

Phenotypic expression of mutations is of particular interest to our understanding of life processes especially when it concerns the evolution of pathogens. In viruses, phenotypic expression of mutations may be manifested not only in symptoms but also in the levels of viral fitness (reproductive capacity of a genotype) and virulence (decrease in host fitness). In the last several years, complete nucleotide sequences, transcriptomes, and proteomes of living organisms have become easier to acquire.

However, these techniques show an instantaneous image of a genome: No indication is given regarding the kinetics of mutations accumulation or the phenotypic expression of mutations in different environments. The study of phenotypic expression is important because natural selection acts on phenotypic expression of mutations in both constant and variable environments.

Our project proposes to fill this gap by focusing on three objectives:

- to characterize the phenotypic expression of adaptive mutations
- to evaluate how the nature of the interactions among mutations is involved in the kinetics of accumulation of adaptive mutations
- to determine how the genotype X environment interactions are involved in fixation of adaptive mutations

We will study the experimental evolution of *Cauliflower mosaic virus* (CaMV, Caulimovirus). CaMV is an appropriate biological model because we have a good knowledge of its biological cycle, and also because it presents a high evolution rate and a large host range. Viral populations will be transmitted from plant to plant during at least 200 generations (\pm 200 days) in either two homogeneous environments (*Arabidopsis thaliana* or *Nicotiana bigelovii*) or a variable environment (alternation of both species). Because CaMV is easy to manipulate (e.g. cloning, sequencing, etc), we will be able to easily determine the kinetics of accumulation of adaptive mutations, and to test their phenotypic expression when alone or in combination in all types of environments. We will work only on mutations that appeared in parallel in independent populations that were subjected to similar directional selective pressures, such as adaptation to the environment. Moreover, we will correlate the phenotypic expression of viral adaptive mutations to modifications of *A. thaliana*'s transcriptome and proteome by comparing the levels of gene and protein expression after inoculation by non-evolved or evolved viral genotypes.

Action carried-out and results obtained:

Since the viral environment is mainly governed by the host, we designed an experimental protocol in which populations of Cauliflower mosaic virus were transmitted from plant to plant in two homogeneous environments (*Arabidopsis thaliana* or *Nicotiana bigelovii*), and also in a variable environment (alternating in both species). One single viral genotype was used to found all viral populations that evolved in parallel for each of these three treatments. During the time of the contract, we designed one technique to quantify viral DNA standardized by host DNA (targeting the number of actin gene). Moreover, we designed a new technique allowing a non-destructive quantification of the deleterious effect of viral infection on the development of the plant (through the measurement of the evolution of leaf area).

After five passages from plant to plant (± 150 viral generations), we established the consensus full-length sequence of each viral populations and detected several fixed mutations in several populations. However, after ten passages, we did not observe these same mutations anymore. Moreover, evaluation of within-host viral load and virulence (i.e. reduction of leaf area due to viral infection) of viral populations that were passages from plant to plant did not allow us to reveal any particular pattern that would be a signature of adaptation (high variance within and among populations). It thus seems that mutations accumulating within viral populations are transitory. Taken all together, these results suggests that in our conditions, the effective size of populations of plant viruses (N_e) is relatively low leading to genetic drift as the predominant force compared to selection. Another hypothesis suggests that the time for accumulation of adaptive mutations is longer than spontaneous mutations and that it would be necessary to continue serial transfers of viruses in order to be able to observe contrasted patterns between the different environments.

Prospects for the future:

Evaluate the effective population size and mutation rate in different hosts

Total Agropolis Fondation funding: € 120,000 (salary for a post-doctoral fellow, running costs)

Funding categorie(s): Agropolis Fondation post-doctoral fellowship

Project duration: 1 March 2008 – 31 May 2011

Keywords: virus – adaptation – mutation – pathogen – *Arabidopsis* – phenotypic – fitness – virulence – evolution – Cauliflower Mosaic Virus

Year of CfP: 2007

Project No: 07059 Completed

Project title: Canopy Architecture modelling for improvement of Genotype-environment description from remote sensing

Unit managing the project: EMMAH (Mediterranean environment and modelling of agri-hydrosystems) (INRA)

Project leader: Frédéric Baret (baret(a)avignon.inra.fr)

Country involved in the project: Spain

Research units from the Foundation's scientific network involved: LEPSE, LISAH

Subthematic axes: STDI-1 (Socio-Technical Dynamics of Innovation 1: *Agri-environmental innovations, agri-ecosystems, resources management*)

Objectives:

Sustainable development relies on application of techniques that will preserve the environment while ensuring the basic human activities to fulfil their needs. Agriculture and ecosystem management plays obviously a central position in such a framework. Canopy functioning models provide very convenient and efficient tools for evaluating environmental footprints of landscape management and agricultural practices. They can be run both in diagnostic and prognostic modes over large areas and provide unique information. However, their use is currently limited because they need numerous inputs, many of them being poorly known and for some of them varying with space and time. Remote sensing offers the capacity to monitor frequently (1/5 1/10 days) wide areas at decametric spatial resolution. Although the road towards combining crop models and remote sensing observations is well defined, advances have been limited by the adequacy between the simple way crop models describe canopy architecture and its dynamic on one hand, and the higher requirements needed for transforming the remote sensing signal into actual canopy state variables through the use of radiative transfer models on the other hand.

The objectives of this project are to develop and evaluate the interest of coupling form (canopy architecture) and function (canopy functioning) models to better relate remote sensing observations to canopy functioning and allow more efficient description of genotype environment over large areas. This will contribute to provide tools for decision making in agriculture and landscape management for sustainable development. This will also prepare interpretation algorithms for the exploitation of the future generation of Earth resources satellites that will be operational at the beginning of next decade within the European Global Monitoring of the Environment and Security (GMES) initiative framework.

The project will focus on a Mediterranean crop to demonstrate the pertinence of the proposed approach: vineyards. This crop has already received attention by the partners from the canopy modelling aspect (STICS-vineyard), canopy architecture description and remote sensing. It presents the interest of having medium complexity architecture. The project will mainly build up the chain of coupled models: radiative transfer, canopy architecture and canopy functioning

Action carried-out and results obtained:

Literature review about two main subjects: (i) Vineyard architecture modeling and (ii) adaptation of crop models to vineyard. The review allowed to find important references for the proposed objectives, that made possible the results retrieved in the activities described below.

Development of a vineyard architecture model: Starting from the architecture measurements of vineyards reported in Louarn (2005), it has been developed a vineyard canopy architecture model. The model describes a 3D scene of vineyard plants taking as input variables architectural and physiological parameters. The actual version is able to describe the 3D architecture of vineyard canopies from burst to maximum leaf area development (not senescence), allowing to introduce agricultural practices such as pruning.

Development of a radiative transfer model based on parametrization of scattering coefficients derived from ray tracing over the 4D canopy architecture model.

Coupling of a functioning model (water balance) accounting for vineyard water stress with the proposed vineyard architecture model; The resulting architecture+water stress model allows the modeling of leaf area dynamics of vineyard under different water stress scenarios.

Validation of architecture+functioning model in direct mode with measured data of leaf area index collected over experimental fields. The results provided by the model were coherent, demonstrating the capability of the proposed models in the prediction of vineyard LAI dynamics

Exploratory analysis about the contribution of vineyard architectural parameters in light interception and reflectance at the canopy scale under different water stress scenario. This analysis highlighted the effect of leaf area management strategies (pruning, trellis system) in the spectral response of vineyard canopies.

Publications :

F. Baret, B. de Solan, R. Lopez-Lozano, Kai Maa, M. Weiss. 2010 GAI estimates of row crops from downward looking digital photos taken perpendicular to rows at 57.5° zenith angle: Theoretical considerations based on 3D architecture models and application to wheat crops. *Agricultural and Forest Meteorology* 150 (2010) 1393–1401

Lopez-Lozano, R., Baret, F., Garcia de Cortazar, I., Bertrand, N. and Casterad, M. A. 2009: Optimal geometric configuration and algorithms for LAI indirect estimates under row canopies: The case of vineyards. *Agricultural and Forest Meteorology*, 149: 1307-1316.

R. Casa, F. Baret, S. Buis, R. Lopez-Lozano, S. Pascucci, A. Palombo and H. G. Jones. 2009 Estimation of maize canopy properties from remote sensing by inversion of 1-D and 4-D models. *Volume 11, Number 4*, 319-334, DOI: 10.1007/s11119-010-9162-9

R. López-Lozano, F. Baret, I. García de Cortázar Aauri, B. Tisseyre and E. Lebon, "Reflectance modeling of vineyards under water stress based on the coupling between 3D architecture and water balance model", *Proc. SPIE 7472, 74720H* (2009); doi:10.1117/12.830057

Prospects for the future:

Within the framework of Vinnotec project, coordinated by B. Tisseyre (UMR ITAP) and P. Zarco-Tejada (IAS/CSIC, Cordoba) the study will continue towards the operation application of 3D models in the estimation of vineyards vigour from remote sensing, more specifically:

- Analysis of uncertainties associated to vineyard architecture in the estimation of canopy biophysical parameters (LAI, porosity, fAPAR...) from reflectance measurements.
- Proposition of an operational methods for canopy vigour estimation from remote sensing imagery over vineyard experimental fields.

Total Agropolis Fondation funding: € 59,746 (salary for a post-doctoral fellow, running costs)

Funding categorie(s): Agropolis Fondation post-doctoral fellowship

Project duration: 2 January 2008 – 30 September 2009

Keywords: canopy – modelling – genotype – remote sensing – vineyard – architecture – sustainable management