APPLIED BIOLOGY, AGRICULTURE AND ENVIRONMENT AT UCL

2009

UCL Université catholique de Louvain

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The Research Administration of the *Université catholique de Louvain* (UCL) has collected the information gathered here, with the precious help of a reading committee composed of the Professors **Jean-François Ledent** (Chairman), Unité d'Ecophysiologie et d'Amélioration végétale, **François Chaumont**, Département de Biologie, **Frédéric Gaspart**, Unité d'Economie rurale, **Marnik Vanclooster**, Unité de Génie rural.

Edited by Anne BOVY (UCL ADRE) – December 2008.
With the contribution of Jean COLIN, Olivier TIRIONS, Martine PLEVOETS and Fanny KLEIN.

Foreword

The world supply of food, and the energy and environment crisis, are major concerns of the present day society. Ever increasing world populations, in combination with an unequivocal changing climate, exert pressures on the food production and on the energy and environmental system which have never been seen before in human history. In such a context, optimal use and management of the world food, energy and environmental resources are needed to meet a sustainable level of development.

Such an optimal use and management should be based on a thorough understanding of the complex relationships that exist between food, energy production, and environment. Studying these complex relationships is the core business of scientists involved in applied biologyl agricultural and environmental sciences.

As a major and complete university of the Communauté française de Belgique, the Université Catholique de Louvain (UCL) disposes of different excellent teams working in the domain of applied biological, agricultural and environmental sciences. Attached to different faculties, schools, departments and research institutes, they reach the critical mass for answering fundamental and applied research questions in this domain. The diversity of approaches developed in different disciplines - which is a typical asset of scientific approaches in a complete university - allows to analyze the multiple dimensions of the research questions in this domain.

This brochure illustrates the competences available at UCL in this domain. Structured along thematic axes, each file presents for a specific field, the associated research resources, a set of references and a list of the main investigators. Voluntarily, the description is not a simple listing of the expertise of the individual teams (which can be consulted at www.uclouvain.be/recherche), but is structured to, illustrate the convergence of the different research approaches developed. We are confident that this brochure will therefore give you an interesting outlook of UCL expertise in this challenging research domain.

Content

D. ECOSYSTEMS AND PLANT PRODUCTION

E. BIOSYNTHESIS – BIOTRANSFORMATION – BIOREMEDIATION

Crop roots genomics and modeling

SENIOR SCIENTIST :

- Xavier DRAYE

Research Field and Subjects

Abiotic stresses increasingly curtail crop yield as a result of global climate change and scarcity of water and nutrients. One way to minimize the negative impact of these factors on yield is to manipulate root system architecture (RSA) towards a distribution of roots in the soil that optimizes water and nutrient uptake. This strategy relies on a clear understanding of the genetic bases of RSA and on the definition of optimal RSA. These two points are the core of our research targets.

On the one side (genetic analysis) we try to establish a repertoire of genes and allelic variants that would be valuable for breeders to modify RSA in a predictable way. This is done with a combination of QTL analysis, structural and functional genomics with a focus on cereals crops. The topic is challenging for a number of reasons. We know for example that RSA is highly responsive to environmental conditions and that this plasticity is also under genetic control. In addition, roots are difficult to observe in their natural environments and artificial systems have to be developped to allow their monitoring. We have come to use aeroponics as such a system, which we are developing as a high-throughput phenotyping platform.

On the other side, the definition of ideal RSA for given crops, environment and yield targets remains a major knowledge gap. Because this involves many scientific disciplines (soil science, hydrodynamics, plant science, bioclimatology, ecology…), we complement experimental approaches with a 3D modeling approach (Functional Structural Plant Modeling) allowing the simultaneous quantitative assessment of the many processes involved in the functioning of the soil-plant-atmosphere continuum. This work also aims at fostering the collaborations between breeders, geneticists, physiologists, crop physiologists and soil scientists (among others) that will be needed before we can turn the emerging genetic data of RSA into improved crop performance.

Products and Services

- Expertise in root system architecture characterisation, throughput imaging, mathematical modeling, quantitative genetics and comparative genomics
- Software :
  - quantification of light interception in virtual canopies (Viewer)
  - interactive analysis of root images (SmartRoot)
  - simulation platform for reengineering of existing models (CrossTalk)

Main Equipment

- Phenotyping platform (aeroponics)
- Root scanners
- Greenhouses, growth chambers
- Rhizotrons

Representative References

- De Dorlodot, S., Forster, B.P., Pages, L., Price, A., Tuberosa, R., Drave, X., « *Root system architecture, opportunities and constraints for genetic improvement of crops* », Trends in Plant Science, vol. 12, n°10, pp. 474-481, **2007**.
- Kramer, E.M., Draye, X., Bennet, M.J., « *Modeling root growth and development* », in Grierson, G., Hetherington, A., Practical Systems Biology, **2008**.
- Draye, X., Pages, L., « *CrossTalk : A simulation platform for the linking of existing soil* », Plant and Atmosphere Models, IEEE CPS/ pma/, pp. 93-100. En ligne, http://doi.ieeecomputer society.org/10.1109/PMA.2006.49

Partnership

- University of Georgia, United States
- University of Nottingham, UK
- INRA Avignon, France

KEY WORDS FOR R & D

Plant growth
Breeding
Cereals
3D modeling
Systems dynamics
Root architecture

SENIOR SCIENTIST

Xavier DRAYE
Xavier.Draye@uclouvain.be
Tel. 32 (0) 10 47 20 92

WEB SITES

http://www.uclouvain.be/ecav.html
http://www.uclouvain.be/en-30461.html

Crop Production, crop modeling, food and non food crops

SENIOR SCIENTISTS :

- Jean-François LEDENT
- Guy FOUCART
- Jean-Marc JOSSART

Research Field and Subjects

Our research focuses on crop management, crop physiology and more precisely crop ecophysiology. The emphasis is on arable crops as maize. Other crops like wheat (which was the main topic formerly), Andean tubers including potatoes, buckwheat, short rotation coppice, cover crops etc., are (or were) also involved through the various projects of the team.

The work on wheat was chiefly on the relations between morphological characters (including geometrical features), physiological characters and yield as well as on the effect of abiotic stresses like low temperatures and drought.

The work on maize covers activities from extension (development) work to more fundamental research. Extension work is based on applied research and a network of farm and station trials on varieties throughout the whole country (Belgium), weed control, fertilisation, and environment friendly crop management.

More fundamental research is on maize growth modelling (including 3D- models), mapping of the land in function of potential yields and risks of crop failure, effect of cold temperatures (physiological but also physical aspects such as diffusion of heat in tissues), relevance of associating cover crops etc.

In reference with the problem of crop diversification, the interest was also focused on crops of minor importance like buckwheat, and short rotation coppice for energy production (electricity) and for environment. Cooperation Programs with South America were chiefly on abiotic stresses (drought, wind: wheat, maize – Argentina; drought, cold: potato- Bolivia); crop modelling maize growth (Chile). We had also programmes on Andean tubers (Bolivia) and on crop associations (crop mixture and competition, 3D modeling; Congo RDC).

Products and Services

Expertise and advising on crop production, crop physiology and crop modeling.

- CIPF A.S.B.L. (Centre Independant de Promotion Fourragère) www.cipf.be

Main Equipment

- Material for conducting field experiments (adapted precision drills, sprayers, small plots harvester (maize) with weighting system, large ovens, etc.
- Material for crop monitoring (light interception, photosynthesis, chlorophyll meter, osmometer, psychrometer, porometer, pressure bomb, phytotron and glasshouses
- Software for crop growth modeling including 3D modeling

Representative References

- JOSSART, J.M., « *Tertiary waste water treatment using short rotation willow coppice in Belgium* », in PALZ, W., (Ed.) Twelfth European Biomass Conference, Biomass for Energy, industry and climate protection, Proceedings from the International Conference held in Amsterdam, The Netherlands June 17-21, vol. 2, pp 1259-1261, **2002**.
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- TOURNEUX, CHR., DEVAUX, A., CAMACHO, M.R., MAMANI, P., LEDENT, J.F., « *Effects of water shortage on six potato genotypes in the highlands of Bolivia (II): Physiological parameters* », Agronomie, vol. 23, pp. 181-190, **2003**.

▸ Halbrecq, B., Ledent, J.F., « *Evolution of flowering, ripening and seed set in buckwheat (Fagopyrum esculentum Moench): quantitative analysis* », European Journal of Agronomy, vol. 23, n°3, pp. 209-224, **2005**.

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▸ Lahlou, O., Ledent, J.F., « *Root mass and depth, stolons and roots formed on stolons in four cultivars of potato under water stress* », European Journal of Agronomy, vol. 22, n°2, pp. 159-173, **2005**.

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▸ Guidi, A., Ledent, J.F., *Promocion de la diversidad de los tuberculos Andinos y sus productos transformados*, Louvain-la-Neuve, Université catholique de Louvain, Cochabamba, Ciuf, Fundacion Proinpa, 114 p., **2007**.

▸ Foucart, G., Mary, M., Renard, F., « *Bilan cultural du maïs en 2006. Récupération exceptionnelle, après un démarrage très délicat* », Le Sillon Belge, vol. 3258, pp. 14-15, **2007**.

▸ Mary, M., Foucart, G., Renard, F., Depoorter, J., « *Nouvelles variétés issues du catalogue Européen. Les nouveaux hybrides du réseau probatoire du CIPF* », Le Sillon Belge, vol. 3261, pp. 41-45, **2007**.

Partnership

▸ ULB, VUB, INRA, UNLPam, Fusagx, CRA-W, VITO, CIP, etc.

KEY WORDS FOR R&D

Maize
Wheat
Potato
Andean tubers
Buckwheat
Cover crops
Drought tolerance
3D modeling
Short rotation coppice
Biofuels
Biomass for energy
Crop management
CERES-Maize

SENIOR SCIENTISTS

Jean-François LEDENT
Jean-Francois.Ledent@uclouvain.be
Tel. 32 (0) 10 47 34 58

Guy FOUCART
Guy.Foucart@uclouvain.be
Tel. 32 (0) 10 47 34 62

Jean-Marc JOSSART
Jean-Marc.Jossart@uclouvain.be
Tel. 32 (0) 10 47 34 55

WEB SITES

http://www.uclouvain.be/ecav.html
http://www.cipf.be/

Process modeling, monitoring, control and real-time optimisation

SENIOR SCIENTIST :

- Denis DOCHAIN

Research Field and Subjects

The main area of expertise is the mathematical modelling of the dynamics of environmental processes, the analysis of the model properties, and the design and application of model-based monitoring and control algorithms by mainly considering mass and energy balance models.

The monitoring and control strategies are applied to stirred tank reactors (dynamics described by ordinary differential equations) as well as to processes, the dynamics of which are described by partial differential equations, such as plug flow reactors, fixed bed reactors or settlers as well as population balance based models (for processes with size-distributed particles or age-distributed cells). Monitoring is related in particular to the design of software sensors that are based on the available knowledge on the process dynamics and the limited number of process variables measured on-line in order to reconstruct on-line the values of the unmeasured key process variables. A special attention is also given to the design and implementation of real-time optimisation methods via adaptive extremum seeking control techniques that allow the process to reach a priori unknown optimal operating points, trajectories or profiles. One of the underlying idea is to incorporate the knowledge about the process dynamics (e.g. basically, the metabolic network and the material balances) in monitoring and control algorithms; moreover the latter are able to deal with process uncertainties (in particular on the reaction kinetics) by introducing, an adaptation scheme.

The applications cover a wide spectrum of water (drinking water) and wastewater treatment (activated sludge, anaerobic digestion, ponds, sequential batch reactors (SBR's), bioremédiation) processes. Several research projects have been carried out in cooperation with industrial partners.

Products and Services

Development and experimental validation of dynamical models
- Design of software sensors
- Design of control algorithms
- Design of real-time optimisation algorithms

Representative References

- SCHOEFS, O., DOCHAIN, D., PERRIER, M., SAMSON, R., « *Estimation of the hydrodynamic and biokinetic models of soil bioremediation processes* », Chemical Engineering Research & Design, vol. 81, n°A9, pp. 1279-1288, **2003**.
- DOCHAIN, D., GREGOIRE, S., PAUSS, A., SCHAEGGER, M., « *Dynamical modelling of a waste stabilisation pond* », Bioprocess & Biosystems Engineering, vol. 26, n°1, pp. 19-26, **2003**.
- GUAY, M., DOCHAIN, D., PERRIER, M., « *Adaptive extremum seeking control of stirred tank bioreactors* », Automatica, vol. 40, n°5, pp. 881-888, **2003**.
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- HARMAND, J., DOCHAIN, D., « *The optimal design of two interconnected (bio)chemical reactors revisited* », Computers and Chemical Engineering, vol. 30, n°1, pp. 70-82, **2005**.
- SAUVAGE, F., WARICHET, D., DOCHAIN, D., « *Dynamical modelling of a wastewater treatment process of the metallurgical industry* », Bioautomation, vol. 6, pp. 1-9, **2007**.
- SAUVAGE, F., GUAY, M., DOCHAIN, D., « *Design of a nonlinear finite time converging observer for a class of nonlinear Systems* », Journal of Control Science and Engineering, ID 36954, vol. 2007, 9 p., **2007**.

Patents

Projets européens
- EOLI ("Efficient Operation of Urban Wastewater Treatment Plants")
- TELEMAC ("TELE-Monitoring and Advanced teleControl of high yield wastewater treatment plants")
- AMOCO ("Advanced Monitoring and Control for Improved Stable Operation of Wood Processing Waste Water Treatment Plants")

Partnership

- INRA, France
- Laboratoire de Biométrie, Montpellier (Dr A. Rapaport), France
- Laboratoire de Biotechnologie de l'Environnement, Narbonne (Dr J. Harmand & J.Ph. Steyer), France
- Université de Technologie de Compiègne, Département de Génie Chimique (Prof. A. Pauss, Dr. O. Schoefs), France
- Ecole Polytechnique de Montréal, Département de Génie Chimique (Prof. M. Perrier), Canada
- Queen's University, Chemical Engineering Department (M. Guay, J. Ramsay), Canada

KEY WORDS FOR R&D

Modeling
Monitoring
Estimation
Software sensor
Control
Real-time optimisation
Population balance

SENIOR SCIENTIST

Denis DOCHAIN
Denis.Dochain@uclouvain.be
Tel. 32 (0) 10 47 23 78

WEB SITE

http://www.csam.ucl.ac.be/

Integrated soil and water resources management

SENIOR SCIENTISTS :

- Marnik VANCLOOSTER
- Charles BIELDERS
- Mathieu JAVAUX
- Sebastien LAMBOT

Research Field and Subjects

Our research team focuses on integration of the transfer of water, solutes and solids within hydrological entities: watershed, reservoir, groundwater body, and region. We also deal with design of hydrological database and information systems. Development and application of integrated hydrological models.

Products and Services

- Integrated hydrological modeling studies
- Optimisation and decision support for sustainable water resources management

Main Equipment

- Integrated hydrological models
- Optimisation models for water resources management

Representative References

- Pinreros Garcet, J.D., « *Metamodelling: theory, concepts and application to nitrate leaching modelling* », Ecological Modelling, vol. 193, n°3-4, p. 629-644, **2006**.

- Pulido Bosch, A., Calaforra, J.M., Vallejos, A., Sanchez Martos, F., Gisbert, J., Ogilvy, R., Vanclooster, M., Frances, I., Jorreto, S., Diaz Curriel, J., Tilmant, A., Van Cauwenbergh, N., Kuras, O., Meldrum, P.I., « *Water scarcity, coastal aquifers and desalination plants* », Congrès GIRE3D, Université Cadi Ayyad, Marrakech, May 23-25, pp 117-124, **2006**.

- Sebari, K., Vanclooster, M., Tilmant, A., « *Optimisation de la gestion conjointe des ressources en eau dans la vallée du Draa (Maroc)* », Congrès GIRE3D, Université Cadi Ayyad, Marrakech, May 23-25, pp. 322-329, **2006**.

- Goor, Q., Persoons, E., « *Sustainable water resources management in the irrigated area of the Draa valley (South-Morocco)* », Congrès GIRE3D, Université Cadi Ayyad, Marrakech, May 23-25, pp. 256-261, **2006**.

- Van Cauwenbergh, N., Pinte, D., Tilmant, A., Vanclooster, M., « *Water management in the Andarax river, Almeria - Part II: decision support system* », Proceedings from International Conference "El Agua Subterranea en Paises Mediterraneos", Aqua-in-Med., Malaga, April 24-28, **2006**.

- Goor, Q., Alia, A., Van Der Zaag, P. Tilmant, A., « *Impacts of the southeastern Anatolia Project in Turkey on the performance of the Tabqa dam and hydropower plant in Syria* », Changes in Water Resources Systems: Methodologies to Maintain Water Security and Ensure Integrated Management, Perugia, Italy, July 08-13, IAHS Publ.315, pp. 1-8, **2007**.

Partnership

- UNESCO – IHE (Delft)

KEY WORDS FOR R&D

Integrated water resources management
Optimization of water resources
Irrigation
Flood management
Drought management

SENIOR SCIENTIST

Marnik VANCLOOSTER
Marnik.Vanclooster@uclouvain.be
Tel. 32 (0) 10 47 37 10

WEB SITE

www.geru.ucl.ac.be

Agricultural, environmental and trade policies

SENIOR SCIENTIST :

- Bruno HENRY DE FRAHAN

Research Field and Subjects

Our research team conducts economic analysis and evaluation of agricultural, environmental and trade policies with economic models at market and farm levels.

Products and Services

- Studies and reports for the European Commission, the Belgian Federal Government, the Region of Wallonia and Non-Governmental Organisations
- Design and development of multi-market models for agricultural and trade policy analysis
- Design and development of farm bio-economic models for agricultural and environmental policy analysis

Representative References

- Dupraz, P., Vermersch, D., Henry De Frahan, B., Delvaux, L., «*The environmental supply of farm households: a flexible willingness to accept model, environmental and resource economics*», vol. 25, pp. 71-189, **2003**.
- Henry De Frahan, B., Elouhichi, B., Harmignie, K., Polome, O., Van Huylenbroeck, P., Buysse, G., J., Lauwers, Fermagut, B., « *La Politique Agricole Commune : une analyse de la réforme récente* », Regards Economiques, vol. 19, pp.2-13, **2004**.
- Henry De Frahan, B., Vancauteren, M., « *Harmonization of food regulations and trade in the Single Market: evidence from disaggregated data* », European Review of Agricultural Economics, vol. 33, pp. 337-360, **2006**.
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- Buysse, J., Van Huylenbroeck, G., Fermagut, B., Lauwers, L., Van Meensel, J., Harmignie, O.,Henry De Frahan, B., Polome, P., « *Positive mathematical programming for agricultural and environmental policy analysis: review and practice* », in WEINTRAUB, A., Bjorndal, T., Epstein, R. Romero, C., (Eds.), Handbook of Operations Research in Natural Resources, International Series in Operations Research & Management Science, F. S. Hillier, Series Kluwer Academic Publishers, pp. 129-154, **2007**.

Awards

- Fulbright Awards, 1998 and 2006
- Hewlett Capacity Building Program Award, 2006

Partnership

- Agricultural Economics Research Institute (LEI), The Hague, The Netherlands
- Ghent University (RUG), Belgium
- Groupe Interdisciplinaire de Recherche en Ecologie Appliquée , Louvain-la-Neuve, Belgium
- Institut National de la Recherche Agronomique (INRA) in Rennes, France
- Swedish University of Agricultural Sciences, Uppasala, Sweden
- University of Bonn, Germany
- University of California (UC), Davis, USA

KEY WORDS FOR R&D

Agricultural policy
Trade policy
World Trade Organisation
Bio-economic model
Multi-market model
Farm model
Farm household income
Risk analysis

SENIOR SCIENTIST

Bruno HENRY DE FRAHAN
Bruno.Henrydefrahan@uclouvain.be
Tél. 32 (0) 10 47 36 73

WEB SITE

www.ecru.ucl.ac.be

Understanding water-related stress at the molecular level and engineering environmental friendly plants

SENIOR SCIENTIST :

- Henri BATOKO

Research Field and Subjects

Systematic sequencing programmes cause the focus of plant molecular genetics to shift away from the identification of new genes toward assigning functions to known genes. Our laboratory is using functional genomic tools applied to the genetic model plant species Arabidopsis to detect and assign functions to in silico selected key genes involved in plant responses to water-related stress.

For example, we are focusing on a membrane protein, highly regulated at the transcriptional and post-translational levels by water-related stress, and induced by the stress hormone abscisic acid. Results so far are indicative of the involvement of this protein in regulating perception/signalling between different organelles in the plant cell under stress. We are working toward understanding mechanistically the function of this protein and the determinant of the relevant regulations. Ultimately, we are interested in tempering with such regulations with the aim of priming crop and non-crop plants to abiotic stress.

We are also conducting evolutionary analysis of genes of interest, for example comparing the activity or performance of a stress responsive gene in glycophytes and halophytes, aiming at using the best possible candidates to engineer stress resistant plants.

Products and Services

- Plant genetic engineering
- Plant cell biology
- Mis-expression and mis-targeting of plant proteins
- Molecular biology
- Protein-protein interactions
- Protein-ligand binding characterization
- Plant abiotic stress physiology

Main Equipment

- Shared state-of-the-art equipments and facilities in molecular biology and biochemistry within the "molecular physiology group" and the "Institut des Sciences de la Vie" (ISV).

Representative References

- Geelen, D., Leyman, B., Batoko, H., Di Sansebastiano, G., Moore, I., Blatt, M., « *The abscisic acid-related SNARE homolog NtSyr1 contributes to secretion and growth: evidence from competition with its cytosolic domain* », Plant Cell, vol. 14, pp. 387-406, **2002**.
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- Lefebvre, B., Batoko, H., Duby, G., Boutry, M., « *Targeting of H+-ATPase to the plasma membrane is not the default pathway and requires soluble structural determinants* », Plant Cell, vol. 16, pp. 1772-1789, **2004**.
- Zheng, H.Q., Camacho, L., Wee, E., Batoko, H., Legen, J., Leaver, C., Malho, R., Hussey, P., Moore, I., « *A Rab-E GTPase mutant acts downstream of the Rab-D subclass in biosynthetic membrane traffic to the plasmamembrane* », The Plant Cell, vol. 17, pp. 2020-2036, **2005**.
- Baroux, C., Blanvillain, R., Betts, H., Batoko, H., Craft, J., Martinez, A., Gallois, P., Moore, I., « *Predictable activation of tissue-specific expression from a single gene locus using the pOP/LhG4 transactivation system in Arabidopsis* », Plant Biotechnology J., vol. 3, pp. 91-101, **2005**.
- Zelany, E., Borst, J.W., Muylaert, M., Batoko, H., Hemminga, M.A., Chaumont, F., « *FRET imaging in living maize cells reveals that plasma membrane aquaporins interact to regulate their subcellular localization* », PNAS, vol. 104, n°30, pp. 12359–12364, **2007**.
- Frison, M., Parrou, J.L., Guillaumot, D., Masquelier, D., Francois, J., Chaumont, F., Batoko, H., « *The Arabidopsis thaliana trehalase is a plasma membrane-bound enzyme with extracellular activity* », FEBS Letters, vol. 581, pp. 4010-4016, **2007**

Awards

‣ The American Society of Plant Biologists "Young scientist's Best paper-of-the-year award", in The Plant Cell, 2001.

Partnership

‣ Member of the « Institut des Science de la Vie » ISV, UCL, Louvain-la-neuve
‣ Partner in the « Action de Recherche Concertée » project: Cellular and molecular responses to water stress in plants

KEY WORDS FOR R&D

Molecular biology
Plant cell biology
Protein trafficking
Genetic engineering
Protein mis-targeting
Water-related stress
Arabidopsis

SENIOR SCIENTIST

Henri BATOKO
Henri.Batoko@uclouvain.be
Tel. 32 (0) 10 47 92 65

WEB SITE

http://www.isv.ucl.ac.be

Water flow through soil-plant-atmosphere continuum

SENIOR SCIENTISTS :

- François CHAUMONT
- Xavier DRAYE
- Mathieu JAVAUX
- Jean-François LEDENT

Research Field and Subjects

Agriculture is responsible for approximately 70% of water use worldwide. Improving the water use efficiency and ensuring an optimal allocation among competing demands in a way that enables farmers to produce food and fiber, minimize pollution and support ecosystems, while meeting social aspirations, is a global challenge for this century.

To achieve this challenge, the understanding of the key mechanisms governing water use by plants is necessary. This covers a broad range of scientific issues going from small scale molecular processes to global scale water management. Research in this area has thus to cross the frontiers of sole plant science.

Genetic improvement is one way to improve crops water use efficiency. However the soil heterogeneity, the plant plasticity and the gap between the molecular and the field scales require additional approaches to be used for providing biotechnology-based solutions to the end-user in the field, i.e. the farmer.

The complementarity of four research groups at UCL enables the integrated study of major steps/aspects of water use by crops: the delivery of water from the soil to the root zone, the exploration of the soil volume by the plant, water transport across cell membranes and tissues facilitated by water channels or aquaporins, and water relationships at the plant and canopy scales. The combination of physical, biophysical and biological knowledge is made possible through strong mathematical modeling grounds. To this goal, 3D models of the soil and of the plant have been developed in UCL labs. A significant effort is now put in the integration of these models to address more of the complexity of the soil/plant system. In addition, multiscale modeling is proposed to level up molecular/cellular processes (water transport across cell membranes) to the scale of the soil/plant system. Modeling approaches are strongly quantitative and enable the assessment of the contribution of different processes (or alterations thereof) to water use (and its improvement). This research will contribute to solving an important question, viz: the definition of optimal plant types for given environmental scenarios. Such ideo-types are clearly lacking today and will offer a scientific framework for targeted improvement of crops.

Products and Services

- Determination of plant water relations
- Determination of soil water relations
- Analysis of gene and protein expression

Main Equipment

- Lysimeter facilities
- Soil characterization equipment
- Scholander bomb
- Cell pressure probe
- All present-day molecular biology and biochemistry equipment

Representative References

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Awards

▸ F. Chaumont: Prix Agathon De Potter de l'Académie Royale de Belgique (2002)
▸ M. Javaux: Editor's citation for excellence in manuscript review by the Soil Science Society of America (2007)
▸ J.-F. Ledent: member of the French Academy of Agriculture

Partnership

▸ Dr. F. Tardieu, INRA - SupAgro, Laboratoire d'Ecophysiologie des Plantes sous Stress Environnementaux, Montpellier, France
▸ Dr. L. Pages et Cl. Doussan, Plantes et Systèmes de culture Horticoles, Domaine du Parc, INRA-Avignon, France
▸ Prof. H. Vereecken. Forschungszentrum Juelich GmbH, Germany

KEY WORDS FOR R & D

Aquaporins
Biophysics
Crop management
Crop physiology
Genetic engineering and breeding
Modeling
Molecular and cellular Biology
Plants
Roots
Root system architecture
Soil
Soil/plant system
Water management
Water relations
Water transport

SENIOR SCIENTISTS

François CHAUMONT
Francois.Chaumont@uclouvain.be
Tel. 32 (0) 10 47 84 85

Xavier DRAYE
Xavier.Draye@uclouvain.be
Tel. 32 (0) 10 47 20 92

Mathieu JAVAUX
Mathieu.Javaux@uclouvain.be
Tel. 32(0) 10 47 37 08

Jean-François LEDENT
Jean-Francois.Ledent@uclouvain.be
Tel. 32(0) 10 47 34 58

WEB SITES

www.uclouvain.be/en-isv.html
www.uclouvain.be/ecav.html

Soil erosion and conservation

SENIOR SCIENTISTS :

- Charles BIELDERS
- Bas VAN WESEMAEL

Research Field and Subjects

Our research team focuses on land degradation and desertification through water erosion, wind erosion and pipe erosion in Europe and tropical areas, extent and associated costs.

Our research fields also covers soil, carbon and nutrient losses through wind and water erosion.

We test soil conservation measures to mitigate erosion and muddy floods: evaluation of the effectiveness of grass waterways, grass buffer strips, reduced tillage, winter cover crops.
Modeling of soil erosion using empirical and physical numerical models.

Products and Services

- Quantification of water flow and sediment discharge at field and watershed scale

Main Equipment

- Water flow measurement equipment : tipping bucket, flume, parshall
- Sediment sampling: tipping bucket with splitter, automatic sampler
- Erosion plots

Representative References

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Partnership

- International crops research institute for the semi-arid tropics (ICRISAT)
- Universiteit Gent
- COST 634 Network on and off-site impacts of soil erosion

KEY WORDS FOR R&D

Water
Wind
Erosion
Soil
Muddy flood
Soil conservation
Model

SENIOR SCIENTISTS

Charles BIELDERS
Charles.Bielders@uclouvain.be
Tel. 32 (0) 10 47 37 14

Bas VAN WESEMAEL
Bas.Vanwesemael@uclouvain.be
Tel. 32 (0) 10 47 20 56

WEB SITE

http://www.uclouvain.be/mila

Soil hydrology

SENIOR SCIENTISTS :

- Charles BIELDERS
- Mathieu JAVAUX
- Sébastien LAMBOT
- Marnik VANCLOOSTER
- Bas VAN WESEMAEL

Research Field and Subjects

Our research focuses on the study of the processes controlling the rainfall-runoff and sediment transport along the land surface. We also study the connectivity of surface fluxes in terms of soils surface properties (roughness, infiltration capacity, etc.); the space-time distribution of moisture content, hydraulic properties and other physical properties of the soil surface by means of geophysical and nearby remote sensing techniques; the water flow and chemical transport processes in soil; the pressure of agro-chemicals on groundwater bodies. We give particular attention to problems related to nitrate and pesticide pollution of groundwater; and the relationships between soil pedologic properties, soil structure and soil hydraulic properties.

Our research fields are also concerning:

- Development and improvement of surface hydrological models, models for the simulation of water and chemical transport in the unsaturated zone at different spatial scales.
- Development of parameterisation schemes in terms of soil structure at different scales.
- Development of techniques for the identification of soil hydraulic and transport properties, in particular inversion techniques.
- Design and evaluation of flood and sediment control technologies and strategies and techniques for sustainable soil and water management.

Products and Services

- Hydrological studies of small hydrological catchments, using advanced hydrological modelling tools, in particular ARC-GIS (geographical data analysis, spatial modelling), MHM-TFM (hydrological modelling), HEC-RAS (hydraulic modelling)
- Soil water and quality studies using soil hydro-ecological models such as the WAVE model (model for water and chemical transport in soil and vadoze environments); the PELEP model (model for the authorisation of plant protection products in Belgium).
- Provider of hydrological data, in particular from the hydrological monitoring network of the site of Louvain-la-Neuve (meteorological data, rainfall network, lysimeter, parshall flume at the outlet of the artificial lake, survey well) and from micro-catchments.

Main Equipment

- Hydraulic equipment. Equipment for river discharge logging: weirs, parshall flumes, hydraulic gauges, gauging station, tipping buckets with different capacity. Hydraulic canal for the calibration of hydraulic instruments
- Surface flow simulator for the study of surface run-off processes under controlled conditions. Rainfall simulator
- Soil physical equipment. Equipment for the determination of the density of soil (pycnometer), soil porosity (mercury porosimetry), soil moisture retention pF- curve (multi-step, pressure chamber), soil hydraulic conductivituty curve (infilrometers)
- Undisturbed soil monoliths and lysimeters for the study of flow and transport processes at the local scale under controlled conditions
- Advanced surface hydrological and soil hydro-ecological models: the meshed hydrological model (MHM), i.e. a spatially distributed hydrological model for the prediction of flow in hydrological catchments, for supporting the design of hydraulic infrastructure such as storm basins, and evaluating the impact of land use on surface flow and flooding risk. The WAVE model, i.e. a model for water and chemical transport in soil and vadoze environments for calculating pressures on groundwater bodies, but also for the crop production and variables related to the bio-geochemical cycles of soils

Representative References

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Partnership

- Geo-instituut, KULeuven, Belgium
- Forschungszentrum Jülich, Germany
- Alterra, Wageningen, The Netherlands
- RIVM, Bilthoven, The Netherlands
- INRA, Orléans, France
- Université Joseph Fourier, Grenoble, France
- BRGM, Grenoble, France
- CRA, Gembloux, France

KEY WORDS FOR R&D

Flooding
Runoff
Soil erosion
River flow
Rainfall
Flood control
Storm basin
Hydrological model
Soil pollution
Groundwater pollution

SENIOR SCIENTISTS

Charles BIELDERS
Charles.Bielders@uclouvain.be
Tel. 32 (0) 10 47 37 14

Marnik VANCLOOSTER
Marnik.Vanclooster@uclouvain.be
Tel. 32 (0) 10 47 37 10

Bas VAN WESEMAEL
Bas.Vanwesemael@uclouvain.be
Tel. 32 (0) 10 47 20 56

Mathieu JAVAUX
Mathieu.Javaux@uclouvain.be
Tel. 32 (0) 10 47 37 08

Sébastien LAMBOT
Sebastien.Lambot@uclouvain.be
Tel. 32 (0) 10 47 37 11

WEB SITE

http://www.uclouvain.be/mila

Hydrogeophysics

SENIOR SCIENTISTS :

- Sébastien LAMBOT
- Marnik VANCLOOSTER
- Mathieu JAVAUX

Research Field and Subjects

Flow of water in terrestrial ecosystems is largely determined by the variability of the physical properties of soil and land use attributes. Given the huge spatial variability, traditional measurement techniques cannot be used to map these properties at the scale of the management unit.

Our research therefore focus on:

- Development and application of new non-invasive hydrogeophysical techniques for imaging, characterising and monitoring soil and subsoil properties and hydrological functions to support sustainable and optimal management of soil and water resources.
- Real-time mapping of soil properties at the field scale with high spatial and temporal resolutions.
- Full-waveform forward and inverse modelling of ground-penetrating radar (GPR) and electromagnetic induction (EMI) data to identify important soil properties, including water content, salinity, texture, and structure.
- Development of prototype GPR and EMI systems.
- Development of integrated hydrodynamic and geophysical inverse modelling strategies for analyzing time-lapse geophysical data and identify key soil hydraulic properties in a mechanistic information fusion framework, including simultaneously data and process knowledge.
- Analysis of the spatial distribution of soil water content and salinity at the field scale. Bridging the gap between ground truth, point measurements and large scale remote sensing.
- Characterization of the electromagnetic properties of materials (soil).
- Development of time and frequency domain reflectometry (TDR and FDR) techniques.
- Application of electric resistivity tomography (ERT).

Products and Services

- Expertise in hydrogeophysics and modelling for solving hydrological problems (flooding, soil contamination, erosion, irrigation design, etc…)
- Expertise in geophysics for shallow subsurface imaging

Main Equipment

- Different GPR systems, based on vector network analyzer technology (ZVRE and FSH6 from R&S) and commercial systems (GSSI SIR 3000), operating either off-ground or on the surface in the range 200 MHz - 4 GHz
- EMI systems (EM38 from Geonics and ultra-wide band system based on vector network analyzer)
- TDR and FDR instruments (Tektronix, TDR100, and multiplexing systems from Campbell)
- ERT (Syscal-Pro, 196 electrodes + switch box)
- 9-m³ laboratory soil model equipped with an automated 3x3-m positioning system for GPR and EMI sensors
- Field measurement platform equipped with GPR, EMI and differential GPS (Leica, cm-accuracy) for real-time mapping applications

Representative References

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- LAMBOT, S., RHEBERGEN J., VAN DEN BOSCH, I., SLOB, E.C., VANCLOOSTER, M., « *Measuring the soil water content profile of a sandy soil with an off-ground monostatic ground penetrating radar* », Vadose Zone Journal, vol. 3, n°4, pp. 1063-1071, **2004**.
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- LAMBOT, S., WEIHERMÜLLER, L., HUISMAN, J.A., VEREECKEN, H., VANCLOOSTER, M., SLOB, E.C., « *Analysis of air-launched ground-penetrating radar techniques to measure the soil surface water*

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▸ Van Den Bril, K., Grégoire, C., Swennen, R., Lambot, S., « *Ground-penetrating radar as a tool to detect rock heterogeneities (channels, cemented layers and fractures) in the Luxembourg Sandstone Formation (Grand-Duchy of Luxembourg)* », Sedimentology, vol. 54, pp. 949-967, doi: 10.1111/j.1365-3091.2007.00868.x, **2007**.

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Awards

▸ Sébastien Lambot received the 3rd Prize for the best European Marie Curie Young Scientists presentation at the 16th Annual Conference Forum Engelberg, Language and the Future, 21-25 May, 2005, Switzerland.

Partnership

▸ International collaborative GPR Centre with Delft University of Technology, The Netherlands
▸ The Research Centre Jülich, Germany
▸ EU-FP7 project DIGISOIL "Integrated system of data collection technologies for mapping soil properties", International

KEY WORDS FOR R&D

Hydrogeophysics
Ground penetrating radar
Electromagnetic induction
Full-waveform inverse modeling
Non-invasive soil characterization
Soil moisture
Soil salinity
Soil hydraulic properties
Real-time mapping
Remote sensing
Tomography

SENIOR SCIENTISTS

Sébastien LAMBOT
Sebastien.lambot@uclouvain.be
Tel. 32 (0) 10 47 37 11

Marnik VANCLOOSTER
Marnik.Vanclooster@uclouvain.be
Tel. 32 (0) 10 47 37 10

Mathieu JAVAUX
Mathieu.Javaux@uclouvain.be
Tel. 32 (0) 10 47 37 08

WEB SITES

www.geru.ucl.ac.be
www.uclouvain.be/mila

Discovery, diversity, application and classification of yeasts

SENIOR SCIENTIST :

- Heide-Marie DANIEL

Research Field and Subjects

Yeasts are an informal and highly diverse group of microscopic fungi that occur predominantly or exclusively in a unicellular state. They are abundant on and in plants and animals and can also be found in soil and water. Their unicellular morphology makes them best suited for liquid substrates and moist surfaces. The significance of yeasts for humans is based on their ability to grow readily and with high metabolic rates on nutrient rich substrates. This has resulted in their importance for the production or spoilage of a variety of foods and beverages since ancient times. Yeasts are also used to produce a variety of metabolites, to perform bioconversions and for biological control of post-harvest diseases of fruits and grains. The ability of yeasts to grow on industrial by-products has lead to their use as single-cell animal fodder or as producers of biofuel. The ability of some species to grow on hydrocarbons as sole source of carbon and energy makes them interesting for the treatment of contaminated water and soils. Recombinant DNA technology has allowed the expression of high-value heterogonous gene products. Yeasts and especially the species Saccharomyces cerevisiae play a significant role in the development of genetics and molecular biology as model organisms. Despite their long-term successful use, some yeast species might be dangerous for animals, humans whose health are critically compromised and more rarely also for plants. Currently the application of yeasts is restricted to a very limited number of species, which do not represent the various abilities of the existing yeast diversity well.

The Mycothèque de l'Université catholique de Louvain, working within the network of the Belgian Coordinated Collections of Microorganisms (BCCM/MUCL) harbors, apart from even larger numbers of filamentous fungi, about 3000 yeast strains representing more than 400 species. This collection is continuously enlarged by new isolates from environmental and industrial sources as well as by type strains of new species. Diversity assessments of natural and man-made environments are performed with the aim of biogeographic and ecological studies, resulting in large numbers of new isolates. The physiological and molecular characterization of these yeasts is forming the basis for the selection of promising yeast strains for industrial applications. Groups of yeasts resulting from physiological and molecular characterization are further characterized by metabolite analysis using innovative approaches such as nuclear magnetic resonance spectroscopy with a specific statistical classification strategy for the detection and identification of discriminant properties. The totality of data is employed for the improvement of yeast classification based on similarity and phylogenetic analyses.

Products and Services

- Identification and characterization of yeasts (classical and molecular)
- Monitoring of production chains for contaminating yeasts including their enumeration and isolation
- Preservation of valuable strains (public, safe and patent deposits)
- Distribution of yeast strains e.g. for food production, the production of specific metabolites, enzymes, etc.
- Education in isolation, culture and preservation methods, identification and taxonomy
- Bio-prospecting and screening

Main Equipment

- A comprehensive database of yeast fermentation and assimilation profiles generated by microplate absorbance readers

Representative References

- Daniel Hm., Meyer,. W., « *Evaluation of ribosomal RNA and actin gene sequences for the identification of ascomycetous yeasts* », Int J Food Microbiol, vol. 86, pp. 61-78, **2003**.
- Himmelreich, U., Somorja, Rl., Dolenko, B., Daniel, Hm., Sorrell, T.C., « *A rapid screening test to distinguish between Candida albicans and Candida dubliniensis using NMR Spectroscopy* », FEMS Microbiology Letters, vol. 251, pp. 327-332, **2005**.
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▸ Tsui, C.K.M., Daniel, H.M., Robert, V., Meyer, W., « *Reexamining the phylogeny of clinically relevant Candida species and allied genera based on multigene analyses* », accepted for FEMS Yeast Research.

KEY WORDS FOR R&D

Yeast
Brewery
Bakery
Biofuel
Biocontrol
Physiology
Diversity
Culture collection
Patent deposit
Identification
Classification
Molecular systematic

SENIOR SCIENTIST

Heide-Marie DANIEL
Heide-Marie.Daniel@uclouvain.be
Tel. 32 (0) 10 47 89 36

Taxonomy, phylogeny, physiology and agro-environmental potential of arbuscular mycorrhizal fungi

SENIOR SCIENTISTS :

- Stephan DECLERCK
- Sylvie CRANENBROUCK
- Hervé DUPRE DE BOULOIS
- Ivan DE LA PROVIDENCIA
- Ingrid VAN AARLE

Research Field and Subjects

Arbuscular mycorrhizal fungi (AMF) form an important ecological and economical group of soil fungi. They develop obligate symbiotic associations worldwide with the vast majority of plant families that dates back as far as 460 million years suggesting their role in the establishment of plants on land. This co-evolution of AMF with plants has resulted in high interdependency. AMF obligatory acquire their carbon from the plant, in exchange for which they improve plant mineral nutrition (especially phosphorus) and health. These fungi thus greatly affect plant community structure, diversity and productivity.

The obligate nature of these organisms has always, and is still making it difficult to study most aspects of the biology of these ubiquitous and fundamentally important fungi, including their functioning and role in environments. Therefore, the laboratory of mycology of the unit of microbiology has developed a world-wide recognized expertise on the in vitro culture i.e. the monoxenic culture of AMF. This system allows the no-destructive, long-term dynamic study of essential aspects of this symbiosis. This technique has been developed in the CEnter of Study on AM Monoxenics (CESAMM) hosted within the laboratory of mycology. Four main research fields are actively conducted based on this technology:

1) Biodiversity

- Systematics of AMF using integrated morphological and molecular tools
- Anastomosis and nuclear exchange: implications for taxonomy, biodiversity and agro-environmental adaptability of AMF.

2) Physiology

- Investigation of the extraradical mycelium of AMF: architecture, function of anastomosis (cytoplasm-protoplasm fluxes) and mechanisms of reparation.
- Gene expression in the extraradical mycelium of AMF subjected to plant signals.
- Role of AMF on the transport of carbon and minerals (phosphorus) as well as of radionuclides (caesium, uranium) and mechanisms involved.

3) Biotic and abiotic stresses

- Influence of the sterol biosynthesis inhibitor fungicides on the AM symbiosis.
- In situ study of the impact of AMF on growth, development, yield and pathogen resistance/tolerance of agriculturally-important plants (potato, banana, etc.)
- Impact of global changes (CO2, nitrogen deposition) on the plant/AMF relationship

4) Glomeromycota IN vitro COllection (GINCO)

- Identification, characterization of AMF (classical and molecular)
- Preservation and distribution of AMF

Products and Services

- Identification and characterization of AMF based on classical and molecular tools
- Preservation of valuable strains (public, safe and patent deposits)
- Distribution of AMF to scientists and industrials for research and application
- Education in isolation, culture and preservation methods, identification and taxonomy
- Education in the in vitro culture of AMF through two yearly international trainings
- Bio-prospecting and screening
- Mass-production of contaminant-free inoculum

Main Equipment

- Scanning Electron Microscope (SEM)
- DNA Sequencer and (Real time) PCR machines
- Denaturing Gradient Gel Electrophoresis (DGGE)
- Climatic Phytotrons
- Laminar hoods

Representative References

- De La Providencia, I.E., Fernandez, F., Declerck, S., « *Hyphae healing mechanism in two arbuscular mycorrhizal fungi Scutellospora reticulata and Glomus clarum differ in response to severe physical stress* », FEMS Microb. Lett., vol. 268, pp. 120-125. **2007**.

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Partnership

- Estacion Experimental del Zaidin, Granada, Espagne
- Pôle de Biotechnologie Végétales, Toulouse, France
- Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-food Canada Ottawa, Canada
- Genetics Institute, Department Biology, Munich, Germany
- Dipartimento di Biologia Vegetale dell'Università, Istituto per la Protezione delle Piante – CNR, Italy
- Division Soil and Water Management K.U.Leuven, Belgique
- Laboratory for Microbiology, University of Gent, Belgique
- Scottish Crop Research Institute, Dundee, Scotland
- Department of Ecological Microbiology, Institute of Environmental Sciences, Jagiellonian University, Poland
- CIP (Pérou), PROINPA (Bolivie), INIAP (Equateur), IES (Cuba), CRBP (Cameroun), CIRAD (Guadeloupe), INRA (France), UCC (Irlande), UAPHYT (France), …

KEY WORDS FOR R&D

Arbuscular mycorrhizal fungi
Global change
Monoxenic (in vitro) culture
Taxonomy
Phylogeny
Fungicides
Traceability
Radio-isotopes labeling
Culture collection
GINCO

SENIOR SCIENTISTS

Stephan DECLERCK
Stephan.declerck@uclouvain.be
Tel. 32 (0) 10 47 46 44

Sylvie CRANENBROUCK
Sylvie.cranenbrouck@uclouvain.be
Tel. 32 (0) 10 47 38 11

Hervé DUPRE DE BOULOIS
Herve.dupre@uclouvain.be
Tel. 32 (0) 10 47 22 26

Ivan DE LA PROVIDENCIA
Ivan.Delaprovidencia@uclouvain.be
Tel. 32 (0) 10 47 22 26

Ingrid VAN AARLE
Ingrid.Vanaarle@uclouvain.be
Tel. 32 (0) 10 47 34 21

WEB SITES

http://www.mbla.ucl.ac.be
http://emma.agro.ucl.ac.be/cesamm/
http://emma.agro.ucl.ac.be/ginco-bel/

Fungal taxonomy and functional diversity in tropical environments (taxonomy / phylogeny / ecology / protection / valorization)

SENIOR SCIENTISTS :

- Cony DECOCK
- Stephan DECLERCK

Research Field and Subjects

Our research focuses on taxonomy, phylogeny, ecology, and biogeography of poroid wood-inhabiting fungi, with a special emphasis on white rot fungi in tropical areas, combining morphological and molecular approaches.

It consists also in a comparison of the distribution and genetic variability of species between continents and type of habitat (open versus closed forests).

Products and Services

- Fungal identification
- Fungal expertise
- Public collection of fungal strains

Main Equipment

- Scanning electronic microscopy at ultra low temperature
- Capillary automated sequencer

Representative References

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Partnership

- Chinese Academy of Science, Prof. Yu Cheng dai, China
- University of Oslo, Prof. L. Ryvarden, Norway
- Centro Forestal CONICET, Prof. M. Rajchenberg, Argentina
- University if Liège, Dr. Gabriel Castillo, Belgium

KEY WORDS FOR R&D

Fungi
Wood-inhabiting fungi
White rot fungi
Taxonomy
Phylogeny
Ecology
Tropics
Rainforest
Biodiversity

SENIOR SCIENTISTS

Cony DECOCK
Cony.Decock@uclouvain.be
Tel. 32 (0) 10 47 82 59

Stephan DECLERCK
Stephan.declerck@uclouvain.be
Tel. 32 (0) 10 47 46 44

WEB SITE

http://bccm.belspo.be/about/mucl.php

Plant pathology and diseases management

SENIOR SCIENTISTS :

- Claude BRAGARD
- Anne LEGREVE

Research Field and Subjects

Our main research fields are concerning plant health, plant pathology, epidemiology of plant diseases caused by fungal, viral and bacterial diseases, ecological and molecular characterization of pathogens. We also study interactions between pathogens, plant and environment.

Our research team is focusing on major plant diseases caused by bacteria, fungi and viruses.
Two major axis are followed. First, the study of plant-pathogen (vector) interactions, with models on major crop. Diseases caused by bacteria (*Xanthomonas tranlucens* on wheat, *Pseudomonas fuscovaginae* on rice), fungi (*Mycosphaerella graminicola* on cereals and *M. fijiensis* on bananas) and viruses (*African cassava mosaic virus, Beet necrotic yellow vein virus, Peanut clump virus, Soil-borne wheat mosaic virus*) are in-depth studied.
Secondly, the epidemiology of the plant pathogen models is studied by analysis of their spatial distribution and diversity at the genome level with the objective to understand the development of plant pathogen epidemics. These studies are also devoted to the development of forecasting models, able to integrate climatological data sets in order to predict the disease outcome.
These two research axis are sustained by our expertise in the field of diagnosis, detection and identification, as well as by services on the use and impact of pesticides.

Products and Services

- PLANT CLINIC, CORDER asbl:

Diagnosis of diseases on crops and advice for control
Analysis of the phytosanitary quality of agricultural products (quarantine bacteria on potato)
Disease assessement in fungicide trials
Fungicide sensitivity testing

- COMITE REGIONAL PHYTO

Advice for environmental friendly use of pesticides

- PROCULTURE

A web based interactive decision support system for fungicide protection of winter wheat
http://proculture web.fymy.ucl.ac.be

Main Equipment

- Bio-security laboratory L3
- Ultracentrifuge
- PCR and real time quantitative PCR, HPLC, Spectrophotometer
- Phytotrons and air conditioned glasshouses, Microscopy (confocal, Nomarski, epifluorescence, video camera)
- Laminar flows
- Electrophoresis, equipment for monoclonal antibody production
- Thesaurus of slides in plant protection

Representative References

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Awards

- Prix Phytophar
- Prix Schepkens en phytopathologie

Partnership

- CRA-W, Gembloux, Unité de Pédologie, UCL-SOLS, Unité de Microbiologie, UCL-MBLA, Belgique
- DSMZ, Braunschweig, Germany
- SCRI, Dundee, UK
- CIMMYT, El Batan, Mexico
- IBMP, Strasbourg, France
- ICRISAT, Hyderabad, India

KEY WORDS FOR R&D

Plant diseases
Plant pathology
Integrated crop protection
Plant viruses
Plant pathogenic fungi
Pesticides and environment
Plant resistance

SENIOR SCIENTISTS

Claude BRAGARD
Claude.bragard@uclouvain.be
Tel. 32 (0) 10 47 40 23

Anne LEGREVE
Anne.legreve@uclouvain.be
Tel. 32 (0) 10 47 34 09

WEB SITE

http://www.fymy.ucl.ac.be/

Parameters influencing flowering and reproductive success in buckwheat (*Fagopyrum esculentum*)

SENIOR SCIENTISTS :

- Anne-Laure JACQUEMART
- Jean-François LEDENT
- Jean-Marie KINET
- Stanley LUTTS

Research Field and Subjects

Buckwheat (*Fagopyrum esculentum Moench*) a distylous pseudo-cereal, is abundantly cultivated worldwide and mainly in Asia and North America. Nevertheless, its floral biology and the factors explaining poor fruit set are poorly studied. Reproductive structures, nectar production, stress responses are studied under controlled conditions. In the field, flowering phenology, fruit set as well as pollinator identity and efficiency allow us to determine several aspects (honeybee activities, absence of pollen transfer limitation, early abortion events).

Products and Services

- Hydroponic cultures, histology, physiological measures (responses to stress), nectar quality (HPLC), pollinators and reproductive success estimations
- Field trials
- Crop Monitoring

Main Equipment

- Growth chambers, germination chambers, pollination kit, GC chromatography, spectrophotometers, osmometer, polyvar

Representative References

- Quinet, M., Cawoy, V., Lefevre, I., Van Migroet, F., Jacquemart, A.L., Kinet, J.M., « *Inflorescence structure and control of flowering time and duration by light in buckwheat (Fagopyrum esculentum Moench)* », Journal of Experimental Botany, vol. 55, pp. 1509-1517, **2004**.
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Partnership

- Jardin Botanique National, Meise (Dr O. Raspé), Belgium
- New York State Agricultural Experiment Station, College of Agriculture and Life Sciences, Cornell University, (Prof. T. Björkman), United States

KEY WORDS FOR R&D

Buckwheat
Water stress
Hydroponic cultures
Pollinators
Nectar production
Seed yield

SENIOR SCIENTISTS

Anne-Laure JACQUEMART
Anne-laure.Jacquemart@uclouvain.be
Tel. 32 (0) 10 47 34 49

Jean-François LEDENT
Jean-Francois.Ledent@uclouvain.be
Tel. 32 (0) 47 34 58

Jean-Marie KINET
Jean-Marie.Kinet@uclouvain.be
Tel. 32 (0) 47 20 50

Stanley LUTTS
Stanley.Lutts@uclouvain.be
Tel. 32 (0) 10 47 20 37

WEB SITES

http://www.uclouvain.be/mila

Forest ecosystem functioning and silviculture

SENIOR SCIENTISTS :

- Quentin PONETTE
- Caroline VINCKE

Research Field and Subjects

The general objective of this research is to understand the reactivity of forest ecosystems, stands and trees to resources (e.g. carbon, nutrients, water) and/or controllers (e.g. light, water), using an ecosystem approach.

Reactivity of stands and trees is assessed through growth, mortality or health condition, and regeneration; input – output budgets are assessed at the ecosystem level.

Resources and controllers may be imposed by the site, or result from selected silvicultural options such as species composition (including species mixture), stand density, fertilizing, and biomass harvesting.

Use is being made of various approaches: in situ monitoring and manipulation of ecosystem characterization, process identification, modelling. The main disciplines are related to forest ecophysiology and ecology, with an applied perspective.

Products and Services

- Environmental monitoring: instrumented permanent plots, data mining and reporting
- Mineral analyses: plant (including woody tissues), water, and soil samples
- Image analyses of plant samples

Main Equipment

- Environmental monitoring: automated meteorological station; soil temperature and soil water content probes; rainfall, stemflow and throughfall automated collectors; lysimeters; sapflow probes; dendrometers; portable infrared gas monitor and soil respiration chamber; LAI 2000; hemispherical photography
- Mineral analyses of plant, water, and soil samples: microwave digestion, HPLC, ICP, C&N analyzer

Representative References

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‣ JONARD, M., ANDRÉ, F., PONETTE, Q., « *Tree species mediated effects on leaf litter dynamics in pure and mixed stands of oak and beech* », accepted for publication in Canadian Journal of Forest Research

Partnership

‣ ULG, Department of Environmental Sciences and Management; Laboratory of Plant and Microbial Ecology, Institute of Botany, Belgium
‣ FUSAGx, Unité de Physique des bio-systèmes, Belgium
‣ RUG, Department of Forest and Water Management; Laboratory of Forestry, Belgium
‣ KUL, Afdeling Bos, Natuur en Landschap, Belgium
‣ INRA-Nancy: Biogéochimie des écosystèmes forestiers; Bioclimatologie et écophysiologie; Croissance et production; Phytoécologie forestière, France
‣ INRA-Bordeaux: unité Ecologie fonctionnelle et physique de l'environnement, France
‣ Division de la Nature et des Forêts (DNF), France
‣ Centre de Recherche de la Nature, des Forêts et du Bois (CRNFB), France

KEY WORDS FOR R&D

Environmental monitoring
Stand dynamics
Silviculture
Water and nutrient constraint
Cycling
Ecophysiology

SENIOR SCIENTISTS

Quentin PONETTE
Quentin.Ponette@uclouvain.be
Tel. 32 (0) 10 47 36 16

Caroline VINCKE
Caroline.Vincke@uclouvain.be
Tel. 32 (0) 10 47 37 29

WEB SITE

http://www.efor.ucl.ac.be/

Vegetation dynamics in semi-natural open habitats and in forests

SENIOR SCIENTISTS :

- Anne-Laure JACQUEMART
- Freddy DEVILLEZ
- Quentin PONETTE

Research Field and Subjects

Vegetation analysis (phytosociology) and vegetation dynamics (fruit set, seed rain, dispersal, seed bank, germination, growth and survival) allow us to elaborate:
1) Predictive analysis of invasion of habitats for invasive alien plant species
2) Monitoring for restoration and management in protected areas
3) Regeneration plans (beech forests)

Products and Services

- Vegetation relevés, seed banks, multivariate analyses, germination tests, dispersal modelling, all items for exhibition about bog biology and conservation

Main Equipment

- Seed traps, germination chambers, vegetation analysis softwares

Representative References

- JACQUEMART, A.-L., CHAMPLUVIER, D., DE SLOOVER, J.R., « *A test of mowing and soil removal restoration techniques in wet heaths of the High Ardenne, Belgium* », Wetlands, vol. 23, pp. 376-385, **2003**.
- JACQUEMART, A.-L., ANGENOT, A., « *Un écosystème original, la tourbière. Le cas des tourbières acides en Belgique* », Probio revue, vol. 4, pp. 257-276, **2004**.
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- PAIRON, M., VERVOORT, A., JACQUEMART, A.-L., « *Les espèces envahissantes, le cas du cerisier tardif (Prunus serotina Ehrh.)* », Silvia Belgica, vol. 4, pp. 50-53, **2006**.
- PAIRON, M., VERVOORT, A., JACQUEMART, A.-L., « *Fiche technique : Le cerisier tardif (Prunus serotina Ehrh.) Ecologie et gestion de cette espèce envahissante* », Silvia Belgica, vol. 4, pp. 55-57, **2006**.
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‣ JACQUEMART, A.-L., ANGENOT, A., DE SLOOVER, J.R., ISERENTANT, I. (EDS), *La Réserve Naturelle Domaniale du plateau des Tailles. Approches géographique, historique et biologique*, Glain et Salm, sous presse, **2008**.

Award

‣ Prix Jean Lebrun, Académie royale des Sciences de Belgique, 2000, to A.-L. Jacquemart

Partnership

‣ Centre de Recherche de la Nature, des Forêts et du Bois (CRNFB, Gembloux)
‣ Biodiversity platform, Belgium (E. Branquart)
- Laboratoire de génétique et d'écologie végétales, Univ. libre Bruxelles (Prof. P. Meerts).
- Laboratoire d'écologie, Unité Sol, Ecologie, Territoire, FUSAGx (Prof. G. Mahy).
- Algemene Plantkunde en Natuurbeheer, Vrije Universiteit Brussel (Prof. L. Triest).
- Jardin Botanique National, Meise (Dr O. Raspé, Dr F. Van Rossum).

KEY WORDS FOR R&D

Vegetation
Reproductive success
Dispersal
Seed banks
Invasive plant species
Bogs
Heathlands
Restoration
Forest regeneration

SENIOR SCIENTISTS

Anne-Laure JACQUEMART
Anne-laure.Jacquemart@uclouvain.be
Tel. 32 (0) 10 47 34 49

Freddy DEVILLEZ
Freddy.Devillez@uclouvain.be
Tel. 32 (0) 10 47 37 29

Quentin PONETTE
Quentin.Ponette@uclouvain.be
Tel. 32 (0) 10 47 36 16

WEB SITES

http://www.uclouvain.be/53484.html
http://www2.ecol.ucl.ac.be/tourbiere/

Fish and marine mammal ecotoxicology

SENIOR SCIENTISTS :

- Jean-François REES
- Cathy DEBIER

Research Field and Subjects

We study the impact of pollutants on fish, such as salmon, eels and deep-sea species as well as on marine mammals, such as seals. Our approach is based on the utilization of cellular models such as erythrocytes, adipocytes and Precision-Cut Liver Slices (PCLS). These models can be applied to the study of toxicants and counteracting drugs on fish and marine mammals.

Products and Services

- Cellular toxicology
- Oxidative damage
- Antioxidant activity
- Fatty acid profile
- Vitamin A and E contents

Main Equipment

- Cell culture facilities
- COMET assay equipment
- Luminescence-based assays
- HPLC

Representative References

- Janssens, B.J., Marchand-Brynaert, J., Rees, J. F., « *Protection of peroxide-treated fish erythrocytes by coelenterazine and coelenteramine* », Free Radical Research, vol. 36, pp. 967-974, **2002**.
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Patents

- 3 patents on new antioxidant compounds from marine animals

Awards

- Delcroix Prize, IZWO, Oostende 1996
- DeLuca Prize, International Society for Bioluminescence and Chemiluminescence, 1998
- Fondation Wernaers 2001

Partnership

- F. ZAL, Station Biologique, Roscoff, France
- M. Collins, British Antarctic Survey, Cambridge, UK
- I.G. Priede, Oceanlab, Aberdeen, UK
- P.P. Pomeroy, Sea Mammal Research Unit, St Andrews, UK
- H.J. Wagner, Tübingen Universität, Tübingen, Germany
- B.J. Leboeuf, D.P. Costa, University of California, Santa Cruz, USA
- D. Crocker, Sonoma State University, CA, USA
- S.Pillet, M. Fournier, Institut Armand Frappier, Canada

KEY WORDS FOR R&D

Oxidative stress
DNA damage
Peroxide
PCB
Antioxidant
Ecotoxicology
Persistent organic pollutant
Marine mammal
In vitro models

SENIOR SCIENTISTS

Jean-François REES
Jf.Rees@uclouvain.be
Tel. 32 (0) 10 47 35 17

Cathy DEBIER
Cathy.Debier@uclouvain.be
Tel. 32 (0) 10 47.37.32

WEB SITE

http://www.uclouvain.be/en-13906.html

Bioenergy and biorefinery : biomass conversion to green chemicals, biofuels and renewable energy carriers

SENIOR SCIENTISTS :

- Spiros AGATHOS
- Juray DE WILDE
- Eric GAIGNEAUX
- Patrick GERIN
- Hervé JEANMART
- Jean-Marc JOSSART
- Jean-François LEDENT

Research Field and Subjects

The research activities covered by this field aim at a better exploitation of biomass as a renewable source of energy and raw material for human (industrial) activities.
Complementary research lines and investigations are developed in different teams and cover the whole conversion chain, from biomass production to product recovery and fuel use. The specific subjects investigated are:

- Ecophysiology and crop management of crop species (*willow, miscanthus*) to be used as a source of biomass raw material. Small scale production of rapeseed oil. (J.F. Ledent, J.M. Jossart)

- Enzymatic and fermentation processes for the conversion of raw biomass (biowastes, crop residues, non-food crops):
1) Specific molecules that can be used as renewable feed stocks in green chemistry, biofuels and energy applications
2) Biocatalyst to be used in biorefinery and white biotechnology processes (P. Gerin, S. Agathos)

- Chemical and physical processes for the recovery of specific molecules from fermentation broths, and the purification and concentration of these molecules to the levels required for their further processing, with integration of energy and environmental constraints (J. De Wilde, P. Gerin)

- Novel rotating fluidized bed type reactor technologies for an intensified combustion or gasification of biomass (J. De Wilde)

- Synthesis and characterization of catalysts required for the processing of biomass and biomass-derived molecules and their conversion to more advanced and useable chemical feed stocks (E. Gaigneaux, P. Ruiz)

- Energy processes and systems used to convert biomass and biofuel to useful energy such as mechanical power, electricity and heat (H. Jeanmart)

Products and Services

- Gasification of biomass: reactor design and industrial process simulation
- Analytical, technological and scientific support for the design, start-up, and operation of conversion (bio-) processes (efficiency, environmental impacts)

Main Equipment

- Various analytical techniques dedicated to the analysis of raw materials and intermediate and final chemicals (solid, liquid, gases)
- Bioreactors (from 5 to 2,500 liters)
- Cold-flow experimental set-up of a rotating fluidized bed in a static geometry
- Cold-flow experimental set-up of a rotating chimney
- PIV: particle image velocimetry and rapid cameras

Representative References

- Fockedey, E., Gerin P.A., De Wilde, J., « *Recovery of Chemicals Produced in Aqueous Medium by Acidogenic Fermentation* », 11th Aachener Membran Kolloquium, Aachen, Germany, march 28-29, **2007**.
- Fockedey, E., Gerin P.A., De Wilde, J., « *Investigation of the Recovery of Chemicals Produced in Aqueous Phase by Acidogenic Fermentation* », International Conference on Renewable Resources and Biorefineries 3 (RRB3), Gent, Belgium, June 4-6, **2007**.
- De Wilde, J., De Broqueville, A., « *Rotating fluidized beds in a static geometry: Experimental proof of concept* », Aiche Journal, vol. 53, n°4, pp. 793-810, **2007**.
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- Nijskens, P., Spies, J., *Production optimale d'une huile de qualité [Optimal production of high quality rapeseed oil]*, report from AGRICOL project, Louvain la Neuve, Université catholique de Louvain, ECAV, 129p., **2006**.

Patents

- A. De Broqueville, J. De Wilde, *Device and method for injecting fluid into a rotating fluidized bed*, (WO/2007/122211), **2007**.

Partnership

- Total Petrochemicals Research Feluy
- Greenwatt (spin-off)
- Xylowatt (spin-off)

KEY WORDS FOR R&D

Biogas
Methane
Esters
Organic acid
Biofuels
Biomass
Process
Fermentation
Separation
Catalysis
Biocatalysis
Combustion
Gasification

SENIOR SCIENTISTS

Patrick GERIN
Patrick.Gerin@uclouvain.be
Tel. 32 (0) 10 47 36 46

Juray DE WILDE
Juray.Dewilde@uclouvain.be

Spiros AGATHOS
Spiros.Agathos@uclouvain.be
Tel. 32 (0) 10 47 36 44

Jean François LEDENT
Jean-Francois.Ledent@uclouvain.be
Tel. 32 (0) 10 47 34 58

Eric GAIGNEAUX
Eric.Gaigneaux@uclouvain.be
Tel. 32 (0) 10 47 36 65

Jean-Marc JOSSART
Jean-Marc.Jossart@uclouvain.be
Tel. 32 (0) 10 47 34 55

WEB SITES

http://www.imap.ucl.ac.be/
www.uclouvain.be/gebi

Fungal bioremediation / biosynthesis

SENIOR SCIENTISTS :

- Stephan DECLERCK
- Estelle ENAUD
- Sophie VANHULLE

Research Field and Subjects

The aim of the biotechnology team of the laboratory of mycology (unit of microbiology) is to solve industrial and environmental issues using the potentialities of fungi and particularly white rot fungi.

Four major topics are developed:
Bioconversion: Screening and development of fungal strains for the production of oxidative enzymes. Development of bioprocesses for the transformation of industrial and agricultural byproducts, into valuable compounds (such as bio-dyes and aroma) or renewable energy sources.
Bioremediation: Screening of fungal strains and enzymes and design of bioprocesses for the safe removal of xenobiotics from contaminated industrial effluents.
Bioprocess expertise: Production and Implementation of new biocatalysts (enzymes and fungi). Studies of natural molecules involved in fungal cell communications in order to improve productivity at macro industrial-scale of the commercially important bio-products. Design of a Granular bio-catalytic material for bioremediation and or biosynthesis of valuable products.
Environmental biosafety: Set-up of biological methods for the monitoring of opportunistic and pathogenic agents associated with composting. Follow-up of xenobiotic detoxification during fungal biotransformation through the use of various biological models (human cells, luminescent bacteria, mutagenic assays, etc).

Products and Services

- Targeted screenings of fungal strains for bioremediation and biosyntheses.
- Immobilization of enzymes on solid carriers.
- Design, start-up and application of bioremediation and bioconversion bioprocesses

Main Equipment

- Fermentors for production of enzymes
- High Performance Liquid chromatography coupled with mass spectrometry (HPLC/MS)
- Capillary electrophoresis (CE)
- Gel electrophoresis (PAGE and SDS-PAGE)
- Spectrophotometry
- Gas Chromatography (GC)
- Integrated bioprocess systems
- Scanning Electron Microscope (SEM)
- Nucleic Acid Sequencer
- Clark electrodes

Representative References

- Trovaslet, M., Enaud, E., Guiavarc'h, Y., Corbisier, A.-M., Vanhulle, S., « *Kinetic characterisation of a Pycnoporus sanguineus laccase (LAC-1) in relation to the textile industry wastewater treatment* », Enzyme and Microbial Technology, vol. 41, n°3, pp 368-376, **2007**.
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Patents

Vanhulle S., Lucas M., Mertens V., Gobeaux B., Bols C-M., Buchon F., Wesenberg D., Agathos S., Corbisier A-M.,

« *Sustainable process for the treatment and detoxification of liquid waste* », World patent WO03/035561, **2002**.

Partnership

‣ Coordination of EU project "SOPHIED". 6th framework Program (FP6), 2004-2008
Partner of EU project "QUORUMSENSING" 6th framework Program (FP6), 2006-2009
Member of suschem plateform

Academic collaborations:
- Université de Liège (Centre d'Ingénierie des Protéines) (Belgium)
- University of Naples (Italy)
- University of Siena (Italy)
- University of Westminster (UK)
- The questor center (UK)
- University of Marseilles (France)
- Instituto de Biologica Experimental e Biotecnologica (Portugal)
- Maria Curie Sklodowska University (Poland)
- Istanbul Technical University (Turkey)
- UFZ-Centre of environmental research Leipzig-Hall (Germany)
- Institute of chemical technology, Prague (Czech Republic)
- University of Pécs (Hongary)
- University of Turku (Finland)

Industrial collaborations:
- Wetlands Engineering (Belgium)
- Realco (Belgium)
- Ovelacq (Belgium)
- Celabor (Belgium)
- Hydrotox GmbH (Germany)
- JenaBios (Germany)
- Labor Grieder (Switzerland)
- Setas Kimya San AS (Turkey)
- Biotransfer (France)
- Stab Vida (Portugal)
- BLC Leather Technology Center (UK)
- Cooperativa tessile di Soci (Italy)
- Conceria Antiba (Italy)
- Tintoria gori manufattura lucchese lane e fibre (Italy)

KEY WORDS FOR R&D

White rot fungi
Bioconversion
Bioremediation
Oxidative enzymes
Enzyme immobilization
Wastewater treatment
Granular biocatalytic material

SENIOR SCIENTISTS

Stephan DECLERCK
Stephan.Declerck@uclouvain.be
Tel. 32 (0) 10 47 46 44

Estelle ENAUD
Estelle.Enaud@uclouvain.be
Tel. 32 (0) 10 47 30 84

Sophie VANHULLE
Sophie.Vanhulle@uclouvain.be
Tel. 32 (0) 479 71 53 21

WEB SITES

http://www.mbla.ucl.ac.be
http://www.sophied.net

Key Words Index