

SUDBIOTECH: A Training Initiative in Plant Biotechnology Dedicated to Scientific Communities in Developing and Emerging Countries

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Abstract

The *SudBiotech* project is targeting PhD and Masters Programmes in Universities and Excellence Research Centres located in developing countries. It proposes an integrative and multidisciplinary approach under the form of a one-week discovery and training itinerary. *SudBiotech* is aimed at addressing various different fields of Plant Biotechnology, under the specific socioeconomic context of scientific communities from these countries. Our main goal is to train students, research staff, deciders, professionals and journalists to the basic knowledge underlying applications of plant biotechnologies, in order to both update the amount of knowledge which is requested at Master's level and to acquire a solid body of information which is indispensable for any decision making, in a field of research which is often the target of political, social and media-related pressure. The team of Professors involved in the project shares a strong experience in teaching and training in overseas French Speaking Universities (AUPELF-UREF projects in Morocco, Tunisia, Togo, Côte d'Ivoire, TEMPUS Programme in Lebanon, AUF-*Actions de Recherche en Réseau* in Benin). The team is composed of senior scientists acting in various complementary fields, namely: Biochemistry/Physiology (A. Nato), Plant Breeding/Molecular Biology (Y. Henry), Tropical Agriculture/Epigenetics (A. Rival). Thanks to these complementarities, *SudBiotech* is able to propose a training itinerary which is diversified and integrated, covering areas from the plant cell and its original potentialities to the most recent industrial applications of plant biotechnologies (GMOs), their public acceptance in developing and emerging nations and their applicability to tropical plant commodities. The training offer is amplified and enriched through the active role of local research and training staff, who are encouraged to actively participate in the *SudBiotech* project under various forms including lectures, field visits, practical sessions, etc. *SudBiotech* relies on original research results, which support and illustrate the various different basic notions evoked during lectures. The case of the bio-production of high added value pharmaceutical products by genetically engineered cells or plants under confined condition is a good example of this integration. Our priority is to establish a long-term, continuous system for training and capacity building, based on appropriate tools for scientific communities in developing and emerging countries: training of PhD students, job opportunities in their native country/region, overseas training, access to scientific information and literature and access to funders and international networks. It is important to note that any training material which is produced under the framework of *SudBiotech* is graciously given without any Intellectual Property Rights to partner institutions, in order to constitute a local basis for training in Plant Biotechnologies in beneficiary countries.

Keywords: capacity building, DNA technology, genetic engineering, electrophoresis, immunology, *in vitro* culture, molecular physiology, PCR, plant biotechnology, proteins, training, transfer of knowledge

Introduction

Struggling for food safety, emerging and developing nations must face numerous challenges. Indeed, the aim of attaining food self-sufficiency is seriously hampered by increasing in population which is far greater than the corresponding increase in food supply.

Besides this major constraint, these nations must cope with limited financial resources, the absence of technology adapted to growth and development, the erosion of biodiversity and growing environmental concerns. According to FAO (2009), severe nutrition problems now affect about

one billion human beings on Earth. In order to compensate the continuous demographic growth, food production will have to increase at the rate of 2.3% per year.

In order to attain such a growth rate in agricultural production, under an unpredictable context of global climatic changes, we will have to make a smart use of any available agro ecological solution.

Among many others, these include:

- the use of phytosanitary treatments
- soil amendments and mitigation of erosion
- the use of organic and chemical fertilisers

- improved agricultural practices and association/rotation of cultures
- irrigation
- plant breeding and biotechnologies

Given the fact that the majority of communities in developing countries lives in rural areas and directly depends on agriculture for surviving, the rural sector is of paramount importance for the fragile economy of these countries.

The expected increase in agricultural productivity will have to take place under the framework of a sustainable agricultural development, without any negative impact on the environment.

In this context, the careful exploitation of plant biotechnology has a role to play in rural development, in the protection of biodiversity and plant genetic resources and in the long term preservation of the environment.

Plant biotechnologies are able to provide amazing tools for plant breeding, as they offer to the breeder the possibility to circumvent natural borders, to fine-tune the creation of new plant varieties and to accelerate the distribution of genetic progress to end users. Thus plant breeders originating from developing and emerging countries must be able to master, monitor and adapt this technology to strategic commodities for their region of origin.

In emerging and less advanced countries, the challenges supported by plant biotechnologies are of paramount importance and the lack of information, training and capacity building in the scientific communities generates a continuously growing demand.

A. Objectives of the Project

The *SudBiotech* training project (University of Paris-Orsay/CNRS/Cirad) presents a multidisciplinary itinerary, aimed at discovering some original characteristics and potentialities of the plant cell.

The project is dispensed by senior academics and research staff working in complementary scientific areas in the aim of integrating various domains of Plant Science (Costa and Shaw, 2007): totipotency, morphogenesis and plant elaboration, mechanisms of cell division, developmental signals, genotype to phenotype, genetic engineering, etc.

Our priority is to establish a long-term, continuous system for training and capacity building, based on appropriate tools for scientific communities in developing and emerging countries: training of PhD students, job opportunities in their native country/region, overseas training, access to scientific information and literature and access to funding opportunities and international networks.

It is important to note that any training material which is produced under the framework of *SudBiotech* is graciously given without any Intellectual Property Rights to partner institutions, in order to constitute a local basis for training in Plant Biotechnologies in beneficiary countries.

B. Challenges

Our partners are Universities and Research Centres located in developing countries (mainly in French speaking Northern and Western Africa at the moment). For our partners, major challenges include the renewal and updating of teaching in Plant Science, and more specifically in Plant Molecular Biology and Physiology, the capacity building of PhD students and junior research staff and lecturers together with the mastering of new emerging technologies and concepts in molecular analysis.

The project is intended as a first step for the setting up of a perennial training network for local research staff, based on the transfer of technologies of potential interest for the development of the country.

It is also important to train a group of young dedicated people who can play a role in the smart decision making requested by Governments on sensitive subjects such as Biotechnologies and Development (Thompson, 2010).

For the involved group of French scientist and their respective institutions of origin, it is important to build up and maintain a sustainable North-South partnership between French Speaking Universities and the French project *SudBiotech* (University of Paris-Orsay, CNRS, Cirad). The challenge is to share and broadcast knowledge and to adapt emerging technologies to the specific needs of societies in the Developing World.

C. Expected outputs

- A continuous process of self-organisation of capacity building in scientific communities in South countries

- Better job opportunities for local junior lecturers and research staff

- An enriching sharing of experiences between North and South and a first step for online training and the generation of multimedia training tools

- Opportunities for French Speaking Universities to share competencies from their academics and research staff on various areas of plant biotechnologies

- An open project for other potential teachers from other French institutions (INRA, CNRS, Cirad, IRD) and Universities for the development of other complementary modules (genetic engineering, plant pathology, etc.).

D. The *SudBiotech* team

The present *SudBiotech* teaching group has been coordinated by Prof. Michel Dron (IPB, University of Paris-Orsay); its present members are:

- Dr. Aimé Nato, Senior Lecturer, University of Paris-Orsay,

- Dr. Yves Henry, Research Director at the Institute of Plant Biotechnology (CNRS, University of Paris-Orsay)

- Dr. Alain Rival, Research Director at Cirad, Montpellier

Yves Henry and Aimé Nato are the authors of a new web site hosted by the University of Paris-Orsay which is dedicated to the multifaceted world of plant biotechnologies (<http://www.cetice.u-psud.fr/cetice/2007/ogm/>)

Alain Rival shares with the team his experience in tropical and Mediterranean plant breeding, an important dimension of the training for students in developing and emerging countries.

The team as whole has a strong expertise in lecturing and tutoring in French Speaking Universities (AUPELF-UREF projects in Morocco, Tunisia, Togo, Côte d'Ivoire, TEMPUS Programme in Lebanon, AUF-Actions de Recherche en Réseau in Benin).

The project has been launched by Professor Alfred Traore, at the University of Ouagadougou (Burkina Faso) in 2007. Prof. Traore is in charge of the Regional Centre of Excellence for Research and Training in Biotechnology which joins several National Universities from Western Africa: Benin, Côte d'Ivoire, Guinea, Mali, Niger, Cameroon, and Togo.

Later, Jininkun a NGO specialised in plant genetic resources in Benin, has partly used our training itinerary for a Seminar organized in Cotonou in December 2007.

SudBiotech has been extended to Benin, under the auspices of Professor Ambaliou Sanni from the Faculté des Sciences et Techniques at the Abomey-Calavi University in Cotonou. Indeed, an International Workshop on Plant Molecular Biology and Biotechnology has been organised

in November 2008, gathering more than 30 students and junior lecturers/researchers originating from the region.

Under the framework of an AUF funded project "Actions de Recherche en Réseau", *SudBiotech* has initiated a new project in 2009, covering a co-supervised PhD work and two International Workshops on site. The first workshop has been organised in July 2009 in Cotonou and a second one will be held in December 2010.

E. How does it work?

The training is basically dedicated to students from Masters 1 and 2 level and PhD schools from Universities in developing and emerging French Speaking countries. The training itinerary has been presented under the form of a one-week workshop to the Universities of Beyrouth (Lebanon), Ouagadougou (Burkina Faso) and Cotonou (Benin). To date, we have trained students with backgrounds in Biotechnologies, Biosafety and Medicine. Targeted audience include not only lecturers and research staff in Plant Biotechnologies, but also NGO staff, lawyers, journalists and members of any involved community.

E.1. On-site training

SudBiotech on site training is organised under the form of a one-week workshop, which includes not only formal

Tab. 1. *SudBiotech* Benin 2009-On site training program: TW= Tutored Work; L= Lecture; EP= Experimental program

Monday	09:00 - 10:30	Official opening- Welcome addresses	15:00 - 16:30	TW1 : In vitro plant morphogenesis
	11:00 - 13:00	Presentation of participants and expectations Presentation of the Training Program	17:00 - 19:00	L1 : Organisation of the genome in Angiosperms
Tuesday	09:00 - 09:30	Debriefing of TW1 Presentation of Experimental program EP1	15:00 - 16:30	EP1 : Calculations and Interpretations
	09:30 - 13:00	EP1 : Identification of biochemical markers of proliferation and differentiation in plants	17:00 - 19:00	EP1 : Joint exploitation of results and conclusions
Wednesday	09:00 - 10:00	Debriefing /discussion: The concept of morphological and metabolic plasticity in plants	15:00 - 16:30	L2 : Genetics and Epigenetics: beyond the double helix
	10:30 - 13:00	EP2 - A simplified protocol for DNA extraction from plants	17:00 - 18:30	TW2 : The Polymerase Chain Reaction (PCR) : Principle and applications in Molecular Biology
Thursday	09:00 - 11:00	L3 - Biotechnologies and GMOs: Which perspectives for African agriculture?	15:00 - 18:00	Public round table on Plant GMOs Video projection and public debate
	11:30 - 13:00	L4 - Natural plant molecules with antiparasitic and anti microbial properties		
Friday	09:00 - 11:00	EP4 : Bioproduction of recombinant proteins in a model plant	15:00 - 19:00	Visit of WARDA International Research Centre in Cotonou On site conferences and discussions with research staff
	11:30 - 13:00	L5 : Plants are natural bioreactors for pharmaceutical products		
Saturday	09:00 - 11:00	EP3 - Detection of transgenes through PCR	15:00 - 16:30	TW3 - Writing of a CV and a collaborative research project
	11:30 - 13:00	L6 - Innovation and scaling up in Biotechnologies	17:00 - 18:30	Evaluation survey and discussions Conclusions and perspectives



Fig. 1A. Extraction of total DNA from plant leaves using a simplified protocol based on kitchen salt and domestic detergent solution. DNA is revealed by ethidium bromide under UV. From Experimental Program 2

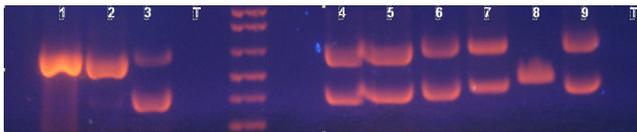


Fig. 1B. PCR detection of transformants. Lane 1 to 3: Non transgenic rice lines. Sample from lane 3 naturally bears the studied gene of sensitivity. Lanes 4 to 9: Transgenic rice lines bearing the expected gene of sensitivity which has been transferred by genetic engineering. T: negative PCR test (no DNA). From Experimental Program 3

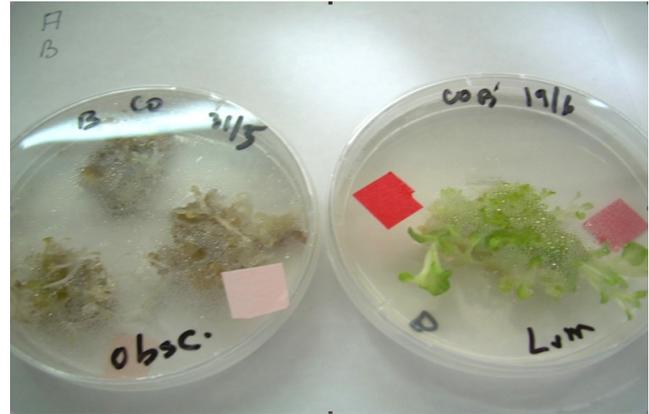


Fig. 1C. Exploring the metabolic plasticity of plants: tobacco *in vitro* cultures cultivated on the same medium in the dark (left) or light (right). After careful observation, total soluble protein are extracted from cultures and biochemical markers are analysed through western blotting. From Experimental Program 1

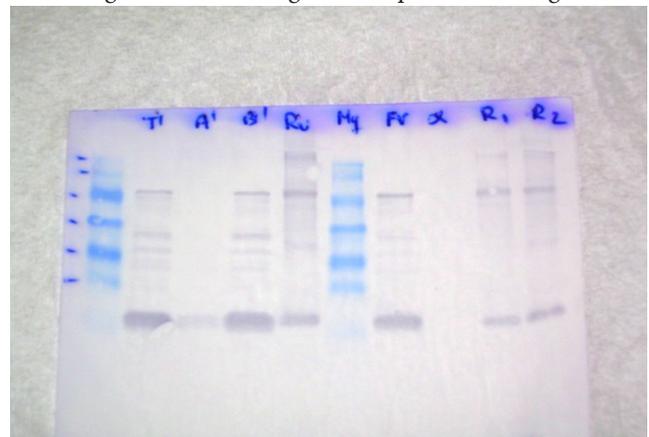


Fig. 1D. Western blot analysis of RubisCo protein in tobacco cultures grown under various different *in vitro* environments and induced morphogenetic responses. From Experimental Program 1

Fig. 1. Results from Experimental Programs as realised in Cotonou AUF Workshop in 2009

lectures, but also literature analysis, practical training and public debates.

The Workshop also includes several sessions dedicated to the future researcher's life of students: scientific CV, projects and reports writing and presentation, literature and data mining through the Internet, carrier and mobility, etc.

Organisers dedicate a lot of space and time for experimental training and critical observation of results (see Fig. 1). Through the results of several evaluation surveys implemented at the end of Workshops, it appeared that this opportunity to actually experience real-life research was one of the major benefits acknowledged by participants.

The workshop timetable also includes informal discussions on various topics (public/private research relationship, researcher's carrier and evaluation, research organisation, mobility, etc.) The organisers share as much time as

possible with students for individual interviews and specific training needs.

A typical program, such as the one proposed for the July 2009 *SudBiotech* Workshop in Cotonou is given in Tab. 1. This timetable gives a realistic idea of the covered scientific areas and the distribution between Lectures, Tutorials and Experimental Programs. A total training time of 50h is proposed to the students.

The final timetable is discussed with the partner university long before the launching of the Workshop, thus enabling any adaptation to students' curricula or specific needs for training and/or information. The *SudBiotech* group really wants the content and organization of the on site training to be as flexible and open as possible.

At the beginning of the Workshop, a group of volunteer redactors is chosen: this group of students will be in charge of writing the final report on a day-to-day basis,

Tab. 2. Draft budget for the creation of the *SudBiotech* Training Case prototype (in euros)

Description	Type of equipment	Amount (€)
Audiovisual	Portable computer	500
	Video projector	1,000
	Portable scanner/printer	500
	Digital Video Camera	500
	Subtotal	2,500
Laboratory	Microfuge	1,000
	PCR thermo cycler	3,000
	Spectrophotometer portable	2,000
	Power generator + stabiliser	2,000
	Electrophoresis cuves	1,000
	Electrotransfer cuves	1,000
	Micropipettes sets	2,500
	Subtotal	12,500
Consumables	Chemicals for DNA/protein extraction, antibodies, nitrocellulose membranes, biochemical reactives	8,000
	Subtotal	8,000
	Grand total	23,000

with the help of *SudBiotech* teachers. It is also in charge of wrapping-up and summarizing the progression of the training itinerary and reporting to the whole group every morning.

By experience, such a program often appears as packed and very dense to the students. This is reflected by most of the results of the Evaluation Survey implemented at the end of Workshop (Tab. 1). In best of worlds, such a program should be organised on a 10-14 days basis, with shorter working days and more time and space left for informal discussions in smaller groups or face-to-face with teachers. Practically, this goal is difficult to reach, given the budget constraints and the restricted availability of members of the *SudBiotech* group, who are involved in several other international projects.

The training project is amplified and enriched through the pivotal role of local research and training staff, who are encouraged to actively participate in the *SudBiotech* project, under various form including lectures, field visits, practical sessions, etc. We consider this point as very important, as the involvement of local staff is the key for the long term existence of the project.

E.2. A new tool for the future: the *SudBiotech* Training Trunk

In order to reinforce the *SudBiotech* initiative on a longer term, the idea is to design a Training Trunk as a physi-

cal tool dedicated to on site training in Plant Biotechnologies.

The trunk will gather the whole set of teaching material for the autonomous implementation of the training itinerary. The *SudBiotech* training trunk will enable to propose not only audiovisual presentations (PowerPoint lectures, bibliography, posters and films) but also all the basic equipment for experimentations in biochemistry and molecular biology (DNA extraction, PCR, electrophoresis, immunoblotting).

Depending on various different requests from partner organisations (Universities, Research and Training Centres, NGOs) and the available dedicated budget, the Training Trunk will be either given as it stands for the continuation of on-site teaching by local staff, or it will be repatriated to France in order to be replenished with consumables and reused for the following session.

On the short term, the *SudBiotech* team will be in charge of the production, multiplication and identification in France of the material dedicated to experimental training: *in vitro* cultivated plant cells and organs, preparation and purification of polyclonal and monoclonal antibodies for immunoblotting, immunotransfer of proteins on nitrocellulose membranes.

As soon as possible, the team will adapt various protocols to local conditions and plant material, in order to promote an autonomous use of the Training Trunk in the near future.

In Molecular Biology, the *SudBiotech* group will constantly transfer new research results and recent technology in order to update the proposed experimental training, such as the identification of nucleotide sequences in genetically engineered material. Our training strategy being based on the experimental approach of biological phenomena, it is important that all the biological situations explored by students are illustrated by clear and concrete biological models.

The strategy is to look for organisations and bodies which can fund the designing of a prototype, made of two different compartments: Audiovisual and Experimental. The total budget for this phase has been estimated at 23,000 euros (Tab. 2).

Performances of the prototype will be analysed during a training session organised on site and evaluated by the *SudBiotech* group, together with participants, students and local staff (who are the end users!). Limitations and drawbacks will have to be identified, according to difficulties encountered on site (logistics, technical constraints) and the needs expressed by partners (program of the session, content of lectures and experimental training, fulfilment of local needs, expectations from the audience)

The local group of teachers will be trained by the *SudBiotech* group to the maintenance and adaptation of the Training Trunk and to the multiplication and preservation of the necessary living plant material. The identifica-

tion of biological systems of local origin will be part of the training.

The prototype will be also useful in the prospection of new partnership and indispensable on site demos. To date, several Universities and research centres are interested in the project; they include the Universities of Sfax (Tunisia), Kaslik (Lebanon), the Universidad Nacional de Colombia in Bogotá and the CERD (Centre d'Etudes et de Recherche de Djibouti).

Conclusions and future directions

The *SudBiotech* project presents an original approach for training and capacity building in plant biotechnology. It is based on on-site interactive training sessions in Universities and research Centres in developing countries.

In the near future, the creation of the *SudBiotech* Training Trunk will enable to undertake these training sessions on a more autonomous way, and to deliver to partner institution a set of ready-to-use training tools for the perpetuation of the Project.

It is expected that the first generation of trained young research will keep the momentum and integrate this global

approach of plant biotechnology to their future training and lecturing programs.

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