Annual report

2004 Sugarcane

CIRAD

Annual report 2004

Sugarcane

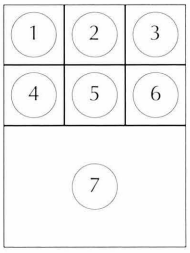
CIRAD

CIRAD, the Centre de coopération internationale en recherche agronomique pour le développement, is the French Agricultural Research Centre for International Development. Its mission is to contribute to the economic development of the tropical and subtropical regions through research on agriculture, training, and dissemination of its results.

It employs 1 850 people, including 950 senior staff, working in the French overseas departments and some 50 other countries. Its budget amounts to approximately 180 million euros.

CIRAD has seven research departments: annual crops; perennial crops; fruit and horticultural crops; animal production and veterinary medicine; forestry; land, environment and people; and advanced methods for innovation in science. CIRAD operates through its own research centres, collaborating national agricultural research systems, universities and international centres, or development projects.

Cover photographs



1 - Checking pheromone traps designed to catch male sugarcane spotted stemborers, *Chilo sacchariphagus* (sugarcane sector, Réunion).
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2 - Sugarcane variety R 570 (Réunion, Savannah site, Saint-Paul).
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3 - Preservation of sugarcane spotted stemborer larvae to monitor parasitism rates (Réunion).
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4 - Sugarcane leaf damage caused by young borer larvae (shotholes).
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5 - Monitoring sugarcane attacked by the stalk borer *Eldana saccharina* (South Africa, Kwazulu-Natal Province).
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6 - Internode attacked by the spotted stemborer in Réunion (borings seriously reduce sugarcane yields).
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7 - Sugarcane field being harvested in Kwazulu-Natal (South Africa).
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Foreword

This Sugarcane Annual Report 2004 was compiled during CIRAD's reorganization process. The former subsector-focused teams were regrouped into different thematic research units in 2004 and 2005. Sugarcane research is now (since 2005) being conducted by internal research units (IRU Sugarcane Farming Systems, IRU Genetic Improvement of Vegetatively Propagated Crops, IRU Decision Support and Biostatistics) and joint research units (JRU PVBMT, Plant Communities and Biological Invaders in Tropical Environments in Réunion; JRU PIA, Polymorphisms of Interest in Agriculture in Montpellier; JRU BGPI, Biology and Genetics of Plant-Pathogen Interactions for Integrated Protection in Montpellier; JRU TETIS, Spatial Information and Analysis for Territories and Ecosystems in Montpellier). 2004 was thus a turning point for everyone and the next Sugarcane Annual Report 2005 will pool all the sugarcane research activities of these units.

The results showcased in this report highlight the dynamic potential of the research teams. The research ranges from fundamental sugarcane genome analysis and pathogen diversity studies to more applied studies including the development of tools and services to support the sugarcane sector and producers, and modelling of sugarcane growth and production. Environment-friendly aspects (sustainable production) are also becoming a major priority in the research projects, along with sugarcane processing and development—especially the transformation of biomass into biofuel. New prospects are opening in this field that will influence the research organization.

Regarding the scientific strategy, collaborations are increasing between CIRAD research units and joint research units (especially with INRA, the French Institut national de la recherche agronomique). These research partnerships are essential to broaden the scientific scope of sugarcane research activities and to gain worldwide recognition for our research. Our more development-oriented research would especially need to be better promoted.

Regarding the geographical strategy, many of the teams are based in the French overseas departments (Guadeloupe and Réunion) and partnerships have been set up in Barbados, Cuba, the Indian Ocean region and southern Africa, Madagascar and South Africa (particularly with SASRI, the South African Sugar Research Institute). This regional cooperation is crucial and we will continue to focus seriously on enhancing the regional thrust of our activities. Available incentive funding should be mobilised through local communities. International partnerships have also been set up in Brazil, especially with ESALQ, the Escola Superior de Agricultura "Luiz de Queiroz", CTC, the Centro Technico de Canavieira, and the Universidade Estadual de Londrina concerning sugarcane modelling and ecophysiology.

I would like to warmly thank all the teams for their committment to enhancing sugarcane research progress. I sincerely hope that we will be able to continue publishing this Sugarcane Annual Report in this constantly changing institutional and scientific setting involving many partnerships.

François-Régis Goebel,
Sugarcane Project Coordinator, CIRAD

CIRAD, Sugarcane Programme, 2004

Genome analysis

Genome analysis research is conducted through a collaboration between the joint research units PIA in Montpellier (JRU Polymorphisms of Interest in Agriculture) and PVBMT in Réunion (JRU Plant Communities and Biological Invaders in Tropical Environments). The aim is to gain insight into genome structure and function so as to generate information and tools that could facilitate sugarcane breeders' task of tapping the available genetic diversity, through:

– development of molecular tools
– analysis of genetic diversity
– mapping of the sugarcane genome
– characterisation of linkage disequilibrium
– genetic analysis of agronomic and disease resistance traits through QTL and association studies.

The Genome analysis research projects a
coordinated by Angélique D'Hont.

Characterisation of linkage disequilibrium in sugarcane

L.M. Raboin, J. Pauquet, J.C. Glaszmann, A. D'Hont

Linkage disequilibrium (LD) measures the nonrandom association of alleles at different loci. The extent of LD in crop species depends on their domestication history and reproduction patterns. The accuracy of pinpointing genes via marker associations and the extent of genotyping required to achieve these results depend on the LD intensity.

Only a few S. *officinarum, S. spontaneum* and *S. barberi* clones have been used in interspecific hybridizations carried out in India and Indonesia at the beginning of the 20th century and the products of these hybridizations have been crossed less than 10 times to give rise to modern sugarcane cultivars. A foundation bottleneck thus had a marked effect on LD—Jannoo *et al.* (1999)[1] showed that LD was maintained in a modern sugarcane cultivar population. Linkage disequilibrium (LD) analysis should confer a predictive value concerning the molecular diversity of useful genes within the vicinity of single points on the genome.

Large-scale AFLP analyses were conducted to genotype a group of 74 sugarcane cultivars. Genetic distances between cultivars were calculated—radial distribution of the population indicates that it has no clearcut structure. Markers were encoded relative to the R570 genetic map in order to accurately determine the relationship between LD and genetic distance on the maps. More than 1 600 AFLP markers were encoded, 408 of which were mapped for cv R570. In this subset, we studied the relation between genetic distances and known statistical associations between all marker pairs using Fisher's exact test. LD was maintained over distances sometimes as much as dozens of centimorgans. The LD intensity sharply declined, however, when the genetic distance between two markers was over 5 cM (Figure 1). In conclusion, LD structure seems to be very suitable for association mapping over the entire sugarcane genome.

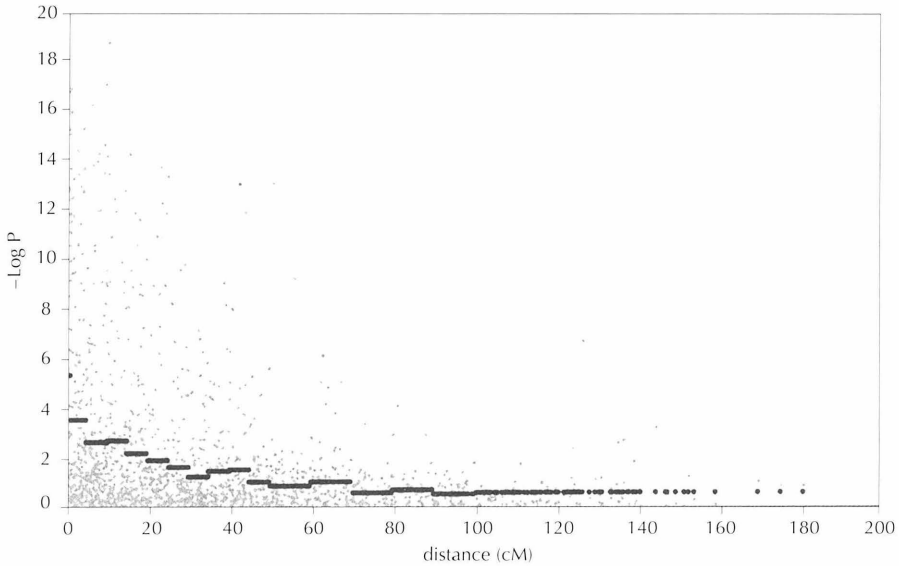


Figure 1. Linkage disequilibrium decreases as the genetic distance increases.

Sugarcane genome structure

Modern sugarcane cultivars have a very complex genetic structure. They are highly polyploid and aneuploid and result from interspecific crosses between the domesticated sugar-producing species *S. officinarum* (2n = 8x = 80) and the wild species *S. spontaneum* (2n = 5x - 16x = 40 - 128). These modern cultivars have 100-120 chromosomes, 15-25% of which are derived from the wild species. Molecular markers are used to gain insight into the structure and function of this complex genome. These markers provide information and tools that will help sugarcane breeders tap the available genetic diversity.

[1] Jannoo N., Grivet L., Seguin M., Paulet F., Domaingue R., Rao P.S., Dookun A., D'Hont A., Glaszmann J.C., 1999. Molecular investigation of the genetic base of sugarcane cultivars. Theor. Appl. Genet. 99: 171-184.

Genetic analysis of disease resistance

Diversity in sources of brown rust resistance

L.M. Raboin, L. Le Cunff (PhD student, Université de Montpellier), H. Telismart, I. Promi, O. Garsmeur, J. Pauquet, J.Y. Hoarau, A. D'Hont

About 100 cultivars were analysed for brown rust resistance or susceptibility through a study of many hybrids bred by CERF (Centre d'essai, de recherche et de formation, Réunion). RFLP analyses of these cultivars were carried out using a set of markers associated with the gene in R570 to determine sources of rust resistance other than this gene. An assessment of the progeny of a cv R570 x MQ 76-53 cross revealed a new brown rust resistance gene.

Positional cloning of the *Bru 1* brown rust resistance gene and physical mapping of the target region

L. Le Cunff (PhD student, Université de Montpellier), O. Garsmeur, J. Pauquet, F. Audebert (DEA graduate student, Université de Montpellier), C. Calatayud, H. Telismart, I. Promi, L.M. Raboin, A. D'Hont

In a project funded by ICSB (International Consortium for Sugarcane Biotechnology), provisional cloning of the major rust resistance gene is currently underway, utilising synteny between grasses, i.e. here between sugarcane, sorghum and rice.

Several datasets were tapped to refine the genetic map of the region around the gene, including:
– the physical map of the sorghum region orthologous to the target region via subcloning and mapping of the BAC ends
–the rice genome sequence by comparing the rice sequence orthologous to the target region with 300 000 sugarcane ESTs of the SUCEST database, and mapping of the identified cDNAs.

In late 2003, the genetic map of the region around *Bru 1* included three markers distally located 0.28 cM from *Bru 1*, one marker distally located 0.14 cM from the gene, three markers at 0 cM, and three markers proximally located 0.28 cM from the *Bru 1* gene. A physically map of the target region had also been initiated with probes mapped around the *Bru 1* gene and using the cv R570 BAC library produced at Clemson University (USA). This library represents 1.3-fold the cv R570 genome. Ten BAC clones were identified in the target region. As sugarcane is a highly polyploid species, these clones represent segments of different homologous chromosomes. Analysis of these BACs revealed that only one of them corresponds to the target chromosome segment (target haplotype bearing the *Bru 1* gene), but it does not span the entire target region. However, at least three BACs homologous to the target haplotype contain the two markers located on both sides of the *Bru 1* gene (mapping at 0.28 and 0.14 cM) and span the entire target region.

In 2004, with the aim of increasing the proportion of BAC clones belonging to the target haplotype, a new library of 100 000 BAC clones was produced from

selfed cv R570 individuals which contain two copies of the target region. BAC clones were organized by pools of six BACs in order to accelerate screening of this library. The library is currently being analysed and three new nonoverlapping BACs belonging to the target haplotype have already been identified. Their terminal ends have been sequenced and analysed. These BACs have also been subcloned and the products sequenced and analysed. The screening of both BAC libraries is under way with all subclones via RFLP and PCR to complete the contig corresponding to the target haplotype.

Genetic diversity of the smut-inducing fungus *Ustilago scitaminea*

C. Calatayud, O. Garsmeur, L.M. Raboin, J. Carlier, A. D'Hont

Sugarcane smut, caused by *Ustilago scitaminea*, occurs in most sugarcane growing regions, except for Papua New Guinea, and the Fiji Islands.

One hundred and forty-two isolated *Ustilago scitaminea* teliospores from 15 countries were analysed with 17 polymorphic SSR loci. All but one of these isolates were found to be homozygous for all of these loci, indicating that this fungus mainly reproduces by selfing. The results of this study showed that the genetic diversity of this fungus is very low in North America and Africa and that all the isolates belong to a single line. In Asia, most of the diversity was detected and this line was also found to be present. Asia could therefore be the origin of this fungus. The high founder effect noted in the overall structure of *U. scitaminea* genetic diversity suggests that this fungus only occasionally migrated from Asia to other continents.

Genetic determination of resistance to smut

L.M. Raboin, H. Telismart, I. Promi

Breeding sugarcane for smut resistance is efficient but requires large-scale testing and there is not yet any genetic control for this resistance. Two complementary strategies were used to identify genome areas involved in smut resistance: genetic mapping of crosses between the resistant cv R570 and the susceptible cv MQ 76-53, and an association study in a population of cultivars.

The genetic map of the biparental cv R570 x MQ 76-53 hybrid is now complete. Overall, 1 666 polymorphic markers were produced with 40 AFLP primer pairs, 46 SSRs and 9 RFLP probes (corresponding to defense genes supplied by SASRI, the South African Sugar Research Institute). Field and greenhouse tests were set up, and are still under way, to analyse the resistance of 200 progeny clones. In parallel, a new rust resistance gene was detected in an analysis of this progeny for rust resistance traits (flowering, Brix, stem diameter) (Figure 2).

A study was undertaken of associations between molecular markers and smut resistance, involving the population that was genotyped to characterise linkage dise-

quilibrium (see above). The population contains 74 cultivars from different sugarcane breeding programmes worldwide. The smut susceptibility or resistance of these cultivars was determined in Burkina Faso under natural infection conditions.

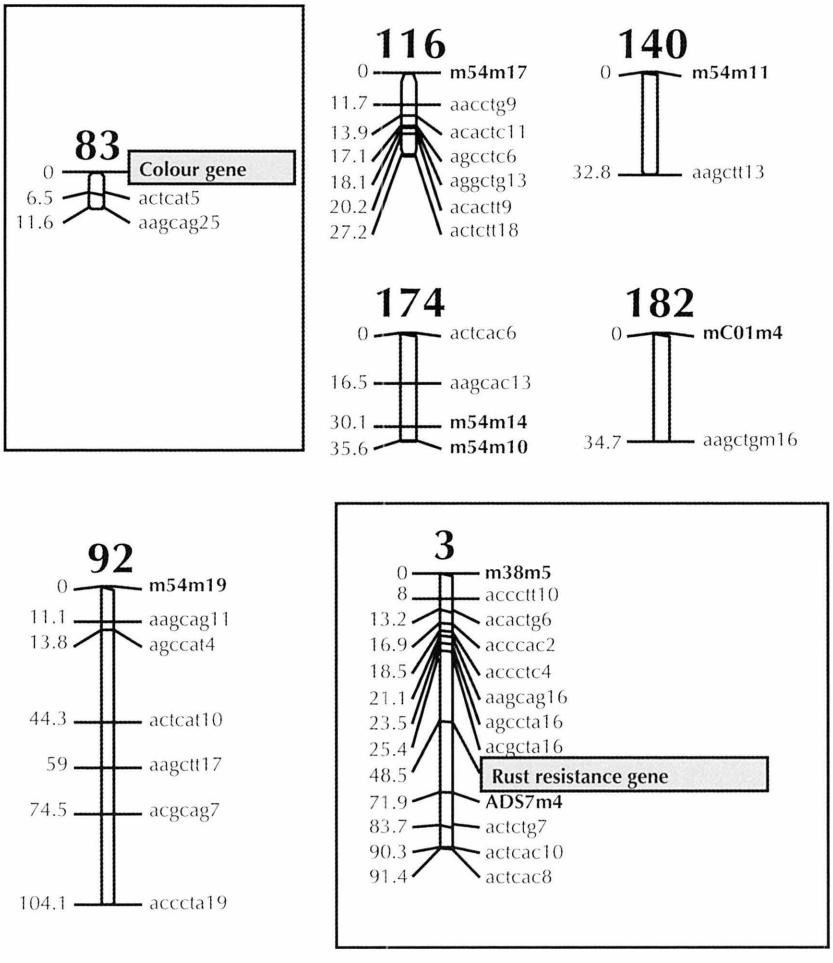
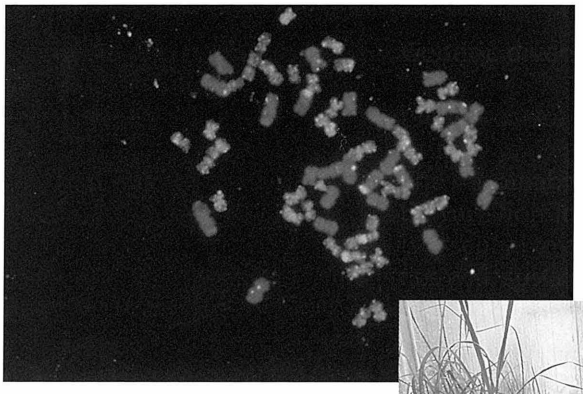


Figure 2. Part of the genetic map of cv MQ 76-53.



Sugarcane genome.
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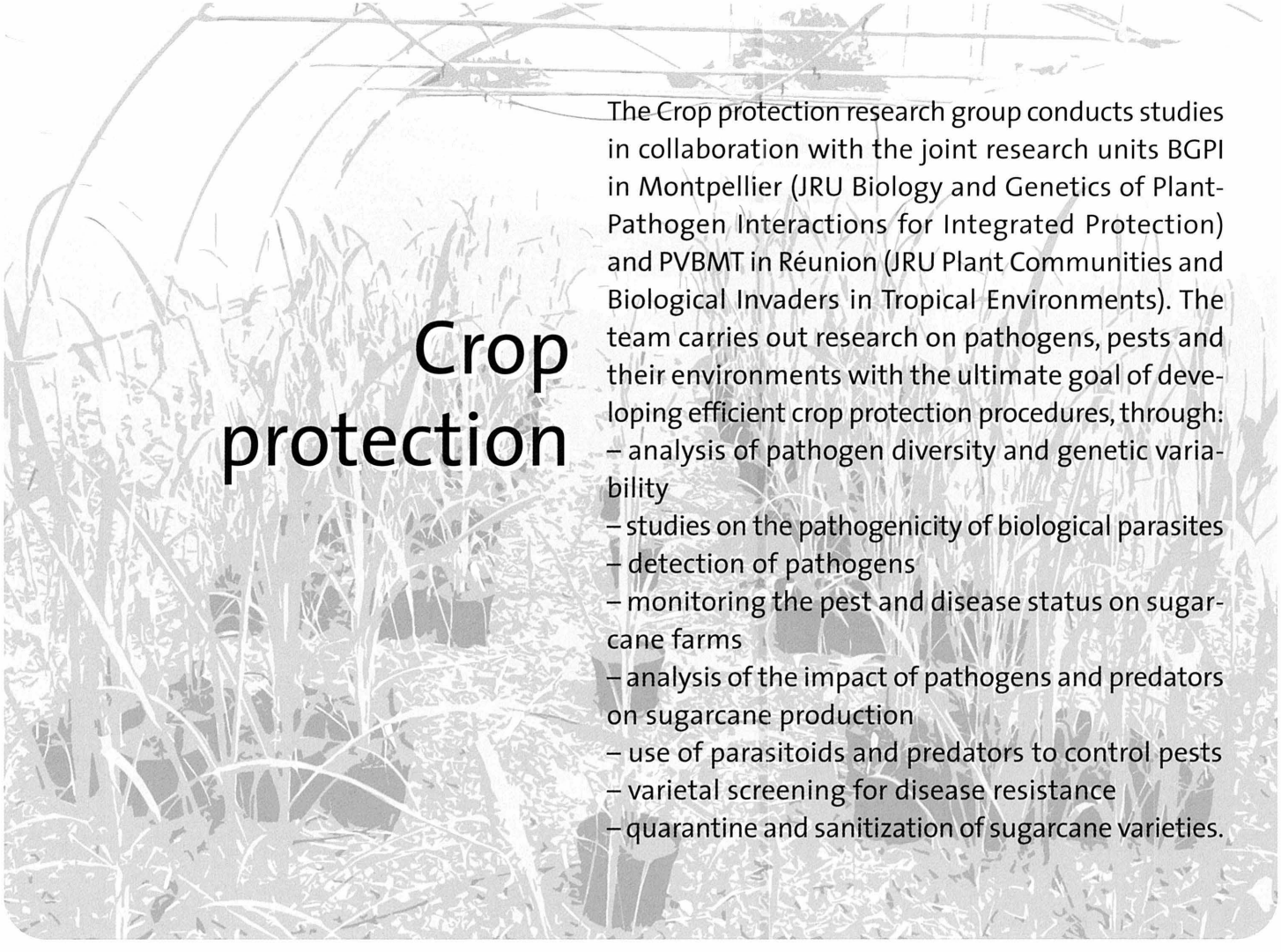
Breeding sugarcane for rust resistance.
© CIRAD, R. Fauconnier

Sugarcane rust symptoms in the field.
© CIRAD, R. Fauconnier



Crop protection

The Crop protection research group conducts studies in collaboration with the joint research units BGPI in Montpellier (JRU Biology and Genetics of Plant-Pathogen Interactions for Integrated Protection) and PVBMT in Réunion (JRU Plant Communities and Biological Invaders in Tropical Environments). The team carries out research on pathogens, pests and their environments with the ultimate goal of developing efficient crop protection procedures, through:

– analysis of pathogen diversity and genetic variability
– studies on the pathogenicity of biological parasites
– detection of pathogens
– monitoring the pest and disease status on sugarcane farms
– analysis of the impact of pathogens and predators on sugarcane production
– use of parasitoids and predators to control pests
– varietal screening for disease resistance
– quarantine and sanitization of sugarcane varieties.

The Crop protection research projects are coordinated by Philippe Rott.

Pathological and epidemiological studies

Sugarcane leaf scald

Albicidin biosynthesis pathways

E. Vivien, S. Cociancich, S. Duplan, I. Pieretti, P. Rott, M. Royer

Xanthomonas albilineans is the causal agent of sugarcane leaf scald. This pathogen produces albicidin, a pathotoxin that has a key role in pathogenicity. This pathotoxin also has antibiotic activity against bacteria responsible for certain human and animal diseases. All genes involved in albicidin biosynthesis in strain Xa23R1 from Florida have been cloned and sequenced. These genes were localized in three genomic regions. XALB1, the first region, consists of 20 genes ranging from *albI* to *albXX*. Three of these genes (*albI, albIV* and *albIX*) code for polyketide synthases (PKS) or for nonribosomal peptide synthases (NRPS). These enzymes are involved in the nonribosomal synthesis of complex molecules. Other genes in the XALB1 region are responsible for resistance, regulation or modification. The two other regions involved in albicidin biosynthesis, i.e. XALB2 and XALB3, each contain only one gene (*albXXI* and *albXXII*, respectively). *albXXI* encodes a phosphopantetheinyl transferase that is required for post-translational activation of the PKS and NRPS enzymes, while *albXXII* encodes the HtpG heat shock protein. The *in silico* functions of each of the 22 genes involved in albicidin biosynthesis were determined, and then an albicidin biosynthesis model was developed and the structure of this pathotoxin was partially simulated.

Glasshouse experiment in Guadeloupe to investigate variation in the pathogenicity of *X. albilineans*, the causal agent of sugarcane leaf scald.
© P. Champoiseau

A production system consisting of all genes identified as being involved in albicidin biosynthesis was constructed. This system was then transferred into a heterologous host (*Xanthomonas axonopodis* pv. *vesicatoria*) and a secondary meta-

bolite resembling albicidin was biosynthesized. This metabolite will have to be purified and its structure identified before it can be formally determined whether it is albicidin. In 2003, the University of Florida and CIRAD jointly patented a process whereby the genes involved in albicidin biosynthesis are used to overproduce albicidin or to produce another antibiotic via metabolic engineering.

Genetic diversity and variation in pathogenicity of *Xanthomonas albilineans*

P. Champoiseau, A. Renier, J.H. Daugrois, J.C. Girard, M. Royer, P. Rott

The sustainability of sugarcane resistance to leaf scald is often hampered by genetic variation in the causal agent and its evolution. Information on this variation is essential to enhance breeding efforts aimed at developing new sugarcane varieties with sustainable leaf scald resistance. Pathogenicity variations in *Xanthomonas albilineans* were hypothesized after renewed outbreaks of this disease were noted in several countries along with its emergence in several geographical areas in the 1980s. Several studies on genetic diversity or variability have been carried out since then by various research teams worldwide. *X. albilineans* was found to be a highly variable pathogen and several serovars, lysovars, genotypes (haplotypes) and pathogenic variants (pathotypes) were identified. So far no correlations have been established between the genetic diversity within the entire genome and variation in pathogenicity.

Bleaching symptom induced by the sugarcane leaf scald pathogen in Guadeloupe on cv B69566.
© P. Champoiseau

Genetic diversity of *X. albilineans* was investigated with genes involved in the biosynthesis of albicidin, a toxin that plays a key role in the pathogenicity of this pathogen. Genomic DNA of 137 *X. albilineans* strains from different geographical regions was hybridized with two probes spanning the three genomic regions involved in albicidin biosynthesis. Fourteen haplotypes and two major genetic groups (ALB-RFLP A and ALB-RFLP B) were identified. Strains isolated during recent sugarcane leaf scald epidemics, or from geographical areas where there was a recent first outbreak of the disease, were found to all belong to the ALB-RFLP B group. On the basis of albicidin biosynthesis genes, the genetic diversity of *X. albilineans* is thus similar to that already described for the entire genome. Moreover, no correlations were noted between the variability in albicidin-encoding genes, the quantity of toxin produced *in vitro* by *X. albilineans*, and pathogenicity groups formed on the basis of symptom severity and the intensity of sugarcane stalk colonization.

One hundred and forty-seven *X. albilineans* strains were sampled in several geographical areas in Guadeloupe and from various sugarcane cultivars. These strains all belong to serovar 1, and the quantity of albicidin produced *in vitro* varies depending on the strain. The pathogenicity of 19 *X. albilineans* strains was analysed on the basis of disease severity and stalk colonization intensity in a leaf scald-susceptible sugarcane cultivar (B69566). Variability in albicidin biosynthesis genes was found to be virtually nil in these 19 strains on the basis of RFLP analyses using specific probes. The genetic profiles of all of these strains—as analysed by pulsed-field gel electrophoresis—were also highly uniform. However, low genetic variability was noted in these strains by AFLP using different primer pairs. Further studies

are required to investigate relationships between this genetic diversity and variation in pathogenicity.

We also amplified and sequenced four adenylation domains in NRPS modules of 16 *X. albilineans* strains representative of the known biodiversity of this pathogen. A study of the polymorphism of these adenylation domains at different levels (DNA, protein and NRPS signature) revealed that these pathogenicity-associated loci are highly conserved. This locus conservation is likely under purifying selection, as indicated by a comparison with the variability of nucleotide and protein sequences of two *X. albilineans* housekeeping genes (*atpD* and *efp*).

A phylogenetic analysis of adenylation domains, however, revealed several groups within the 16 *X. albilineans* strains. One of these phylogenetic groups reflects the genetic diversity already identified by RFLP and AFLP analyses. This group contains only four *X. albilineans* strains that are all involved in renewed outbreaks of sugarcane leaf scald—as also confirmed by the results of a complementary study conducted with 30 other *X. albilineans* strains.

The quantity of albicidin produced *in vitro* in agar and liquid media varied in the 16 *X. albilineans* strains. No correlations were noted, however, between the quantity of albicidin produced *in vitro*, pathogenicity groups and genetic diversity of the pathogen. NRPS loci contributing to synthesis of the primary albicidin structure thus do not seem to be responsible for the observed differences in pathogenicity in *X. albilineans* strains.

Airborne transmission of *Xanthomonas albilineans* in Guadeloupe and Réunion

J.H. Daugrois, P. Champoiseau, R. Boisne-Noc, S. Joseph, M. Payet, L. Costet

In Guadeloupe, epiphytic *Xanthomonas albilineans* populations have a key role in sugarcane leaf scald propagation. A previous study demonstrated that the time this pathogen takes to colonize leaf surfaces and subsequently infect the plants can vary depending on the sugarcane variety. A new study was recently set up as a complement to this preliminary study which had only been carried out on two varieties. Preliminary results obtained with six sugarcane varieties confirmed the previous data, i.e. the time to reach high epiphytic populations of *X. albilineans* varied in different varieties. This difference was especially obvious in variations in pathogen densities collected in dewdrops. However, densities of this bacteria on the surface of leaves at the end of the rainy season did not markedly differ between the six varieties. These results, which were obtained after a year of exceptionally high rainfall, should be checked under more normal seasonal climatic conditions and the results should also be assessed in terms of the susceptibility of the varieties analysed.

In Réunion, it is thought that *X. albilineans* might infect plants via airborne transmission, but this has yet to be documented. This type of transmission could have a detrimental impact, for instance, when disease-free nursery plants are used to sanitize sugarcane fields. A test was set up on 3 September 2004 at the Ligne Paradis research station using healthy tissue-cultured plants, i.e. cv R570 (44 plants) and cv B69566 (45 plants). Sugarcane stools were planted in alternate and staggered patterns in a field located close to a sugarcane varietal collection plot.

The first sampling was carried out on 5 October 2004 by collecting water droplets within the leaf sheath and these droplets were then plated on semi-selective culture medium to isolate *X. albilineans*. The pathogen was not detected in the 89 collected samples (one per micropropagated plant). This sampling is to be continued in 2005.

Xanthomonas-induced diseases: genetic diversity and variation in pathogenicity of *Xanthomonas* pathogens of sugarcane

L. Costet, M. Payet

Bacterial diseases of sugarcane are most effectively controlled through preventive measures, so efficient and specifically focused screening of resistant cultivars is required in varietal improvement programmes. A thorough overall understanding of the pathogen diversity and variability is necessary to enhance breeding efficacy.

Similar leaf symptoms

Several *Xanthomonas* species infect sugarcane and induce leaf symptoms that are often similar (necrosis, streaks, bleaching, etc.):

- *X. albilineans*, causal agent of leaf scald
- *X. axonopodis* pv. *vasculorum* and *X. vasicola* pv. *vasculorum*, which cause gumming disease
- *X. vasicola* pv. *holcicola*, responsible for bacterial streak in sorghum
- *Xanthomonas* sp., causal agent of false red stripe disease in Brazil.

The 2003 biochemical diversity (Biolog plates) and genetic diversity (BOX, ERIC and REP-PCR) results were confirmed in 2004 with more than 100 strains of *X. axonopodis* pv. *vasculorum*, *X. vasicola* pv. *vasculorum*, *X. vasicola* pv. *holcicola*, *X. sacchari*, *Xanthomonas* sp. and *Xanthomonas albilineans*. An AFLP method was developed with a capillary sequencer and encouraging results were ob-tained in the first tests carried out on 15 representative strains from the *Xanthomonas* sugarcane pathogen collection and five enzyme pairs. Three of the five enzyme pairs tested are interesting candidates for AFLP analysis of the diversity of these *Xanthomonas* strains.

Two sugarcane varieties (R570 and B34104) were inoculated with 16 *Xanthomonas axonopodis* pv. *vasculorum* strains and five *X. vasicola* pv. *holcicola* strains in order to determine the pathogenicity of *Xanthomonas* strains collected in a survey carried out in Réunion in April 2004. The results are currently being analysed.

Sugarcane yellow leaf

Characterization of the genetic diversity of *Sugarcane yellow leaf virus*

Y. Abu Ahmad, M. Royer, P. Rott

Yellow leaf is caused by *Sugarcane yellow leaf virus* (SCYLV), a single-stranded RNA virus of the *Luteoviridae* family. Five SCYLV isolates from different geographical regions and supposedly representing different virus strains were entirely sequenced (BRA-YL1, PER-YL1, REU-YL1, REU-YL2 and REU-YL3), and three were partially sequenced (CHN-YL1, COL-YL1 and CUB-YL1). Phylogenetic analyses confirmed the presence of at least four SCYLV genotypes (BRA for Brazil, CUB for Cuba, PER for Peru and REU for Réunion). Differences between genotypes seemed to occur throughout the genome, but some genomic regions were more variable than others.

Virus transmission pattern

Sugarcane yellow leaf virus (SCYLV) is spread in the field by planting of infected cuttings and it is transmitted from plant to plant by the aphid vector *Melanaphis sacchari* in a persistent, circulative and non-replicative manner.

Isolates found in sugarcane varieties from various countries were also genotyped using primers that enabled rapid and specific identification by RT-PCR of three

of the four SCYLV genotypes. The results indicated that several genotypes of the virus can coexist in the same sugarcane-growing area or in the same plant, but only one genotype or a major genotype is present in some geographical areas.

Variation in pathogenicity of *Sugarcane yellow leaf virus*

Y. Abu Ahmad, J.C. Girard, L. Costet, J.M. Lett, S. Nibouche, M. Payet, M. Muller, P. Rott

In May 2004, two sugarcane varieties (R570 and SP71-6163) naturally infected by SCYLV isolates from different geographical areas (Brazil, Colombia, Florida, Guadeloupe, Hawaii, Mauritius, Réunion), were planted in a tunnel greenhouse in Montpellier in an experiment with a block design and 10 replications. The goal of this trial was to confirm the results of a similar trial that was conducted in 2003. The plants were monitored once a week and yellow leaf syndrome symptoms were scored on a 0-5 scale. TBIA was used to detect the virus in each sugarcane plant after 5 months of growth in the greenhouse. The results showed that the SCYLV behaviour (number of infected vascular bundles, virus density in leaves, impact on sugarcane stalk growth) can vary in a sugarcane plant depending on the area where it was originally cropped. These preliminary results suggest that pathogenicity levels can differ between SCYLV strains. These finding should be confirmed by repeating the experiments in 2005.

Our attempt to transmit purified SCYLV to tissue cultured sugarcane plants via the *Melanaphis sacchari* aphid was unsuccessful. We thus decided to opt for direct transmission of the virus from infected to healthy plants through the aphid vector. SCYLV transmission from infected to healthy tissue cultured sugarcane plants was thus shown to be possible.

Finally, a new *Melanaphis sacchari* rearing method was developed in Réunion. It involves propagating aphids on detached leaf fragments that are kept alive in glass tubes. This rearing method will be used in 2005 to transfer SCYLV genotypes from infected plants (in the greenhouse) to healthy plants (tissue cultured) in order to study variation in SCYLV pathogenicity.

Epidemiology of *Sugarcane yellow leaf virus* and sugarcane resistance mechanisms in Guadeloupe

J.H. Daugrois, S. Joseph, R. Boisne-Noc, C. Edon, N. Sauvion

It is essential to determine the risk of infection of healthy plants under the tropical conditions of Guadeloupe in order to design the most suitable control methods. No information is currently available on the impact of yellow leaf in Guadeloupe, or on sugarcane resistance mechanisms against this disease. Studies were carried out in Guadeloupe in 2004 with the aim of gaining further insight into processes involved in the contamination of disease-free plots and investigating potential sources of resistance of sugarcane varieties to the insect vector.

Melanaphis sacchari, the insect vector of SCYLV, was monitored from the second week after transfer of disease-free sugarcane cv SP71-6163 plants to the field. The aphid had colonized all 1 800 plants of this variety 18 weeks after field planting. SCYLV was detected by leaf tissue blot immunoassays in 12 of the 1 800 plants 7 weeks after field planting. At this time, the *M. sacchari* populations were in an

exponential growth phase. At the end of the cycle, after 8 months of growth, the SCYLV infection rate of the plot was 25%. Infected plants were randomly distributed at the beginning of the infection period, but the pattern became aggregative by the end of the cycle. Complementary statistical analyses are in progress to accurately describe the contamination of a disease-free sugarcane plot located close to infected plants.

Antibiosis (impact on the reproduction cycle) and antiexenosis (repellent effect or nonpalatability) resistance tests were carried out with 15 commercial sugarcane varieties or varieties derived from breeding programmes. Total antibiosis resistance was noted in four varieties and partial resistance was detected in five varieties. An antixenosis effect was documented in two varieties. Therefore, among the SCYLV transmission resistance mechanisms, the genotype effect of the host plant on insect populations must be taken into consideration.

Disease control

Assessment of CERF sugarcane varieties for resistance to gumming disease and leaf scald in Réunion

L. Costet, M. Payet

The aim of the assessment of CERF (Centre d'étude, de recherche et de formation, Réunion) sugarcane varieties was to provide support for varietal improvement programmes. Experiments were thus carried out under controlled inoculation conditions to ensure that these varieties had a high enough resistance level to protect them against the main sugarcane diseases present on the island of Réunion.

In July 2004, a field trial was conducted at La Mare research station to screen 29 CERF varieties and five MSIRI (Mauritius Sugar Industry Research Institute) varieties for resistance to gumming disease and leaf scald.

An additional leaf scald screening test was carried out at La Mare—it was a replication of the trial conducted at Saint-Benoît in 2002-2003 on around 30 sugarcane varieties to validate the leaf scald resistance assessment method based on the extent of stalk colonization.

Pest and disease monitoring and control in the CERF quarantine unit in Réunion

L. Costet, M. Payet

No new pathological phenomena have been recently reported in Réunion. However, a new yellow spot epidemic occurred in May 2004, affecting all cropped varieties, especially R570 and R579, and specifically in the Hauts de l'Est region (Grand Etang, Salazie, etc.). This was similar to the epidemic that occurred during the same period in 2003. New CERF sugarcane varieties should be

assessed for their yellow spot resistance if this outbreak pattern becomes recurrent in Réunion.

No unusual phytopathological cases were noted during visits to the CERF sugarcane quarantine unit in June and November 2004. The 24 international varieties imported from the CIRAD quarantine unit in Montpellier were released. In November 2003, however, *Sugarcane yellow leaf virus* (SCYLV) was detected in four MSIRI varieties, which were subsequently destroyed.

Sugarcane disease monitoring in Guadeloupe and the West Indies

J.H. Daugrois, R. Boisne-Noc, S. Joseph, F. Caray, P.Y. Techney, E. Muller, M.L. Caruana, B. Vercambre

Leaf fleck

In 2004, a pest and disease survey focused on the distribution of *Sugarcane baciliform virus* (SCBV) in Guadeloupe. SCBV, which causes leaf fleck, was detected by IC-PCR in almost all tested varieties throughout the island. SCBV is not considered as an economically important sugarcane pathogen, but a closely related badnavirus (*Banana streak virus* or BSV) is highly pathogenic to bananas. Moreover, it has been shown that SCBV can be transmitted to banana plants under experimental conditions, but this type of transmission was not documented in this survey.

Ratoon stunting disease

As part of a cooperation programme with WISBEN (West Indies Sugarcane Breeding and Evaluation Network), sugarcane stem tissue blot immunoassays were performed on samples collected in the Dominican Republic (Central Romana) and Jamaica to screen for the presence of *Leifsonia xyli* subsp. *xyli*, which causes ratoon stunting disease (RSD). Stem tissue immunoimprinting on nylon membrane was performed in the countries from which the samples originated, and the products were sent to Guadeloupe for serological assay and analysis of the results. *L. xyli* subsp. *xyli* was detected for the first time in Jamaica and its presence was confirmed in the Dominican Republic.

Pathological support for sugarcane varietal improvement in Guadeloupe

J.H. Daugrois, R. Boisne-Noc, S. Joseph, S. Beramis

In 2004, the FR97 sugarcane variety series was assessed for resistance to smut (*Ustilago scitaminea*) and ratoon stunting disease (*Leifsonia xyli* subsp. *xyli*), while the FR00 and FR01 series were assessed for leaf scald (*Xanthomonas albilineans*). Six varieties (14%) of the FR97 series were found to be susceptible to smut and 12 varieties (28%) were just partially susceptible. One promising variety and two foreign varieties tested were also susceptible to smut (FR89-423, R575 and B86690). Varieties of the FR97 series were not very susceptible to ratoon stunting disease, but around 10 of them are considered to be potentially susceptible.

New screening test

Breeding and screening of resistant sugarcane varieties is the most efficient disease control method.
In 2004, resistance screening tests were modified to optimise breeding of resistant varieties.
Tests to screen for smut resistance in FR varieties are thus now carried out in the third selection stage.
This procedure facilitates assessment of smut resistance of sugarcane plants prior to planting multisite trials outside of the research station and before dispatching varieties to CIRAD's quarantine unit in Montpellier.
Tests for resistance to ratoon stunting disease will be conducted on varieties selected for multisite trials.
As the results can vary substantially, a more accurate experimental design will be used to determine leaf scald resistance of varieties at the end of the selection cycle.

Concerning leaf scald, several varieties had a higher *X. albilineans* stalk colonization level than the susceptible control (B69379). However, the tested varieties could not be objectively screened for leaf scald resistance because of the high coefficient of variation obtained for the control plants in this trial.

Tests were conducted to screen 230 varieties from CIRAD's sugarcane germplasm collection in Guadeloupe for two vascular pathogens, i.e. *Sugarcane yellow leaf virus* (SCYLV) and *Leifsonia xyli* subsp. *xyli*. These varieties have been used for hybridizations in recent years. The incidence of each pathogen was measured using the stem tissue blot immunoassay technique. The criteria considered were the number of infected stalks and the number of vessels colonized by each pathogen. Hence, 41 varieties were classified as susceptible to yellow leaf and only 23 varieties were susceptible to ratoon stunting disease. Part of the sugarcane germplasm collection will be analysed by this procedure every year until all varieties are characterized. Visual evaluations of smut and leaf scald were carried out in 2004 on 710 varieties of the collection. Ten of them were classified as susceptible to smut, and 14 as susceptible or very susceptible to leaf scald.

Sugarcane quarantine

J.C. Girard, M. Chatenet, J.F. Bousquet, M.J. Darroussat, E. Fernandez, M. Giner, R. Habas, M. Muller, T. Vicaire, P. Rott

Quarantine data management

The SISTER (Système d'information pour le stockage, le traitement et l'évaluation des résultats) software package is currently being adapted to meet quarantine needs. This software could ultimately be used to manage a range of quarantine data (varieties, origins, parents, quarantine stages, transfer to tissue culture, disease detection tests, etc.) and to know the exact status of each variety at any time.

Quarantine located remote from sugarcane-growing areas

CIRAD's sugarcane quarantine unit in Montpellier has a leading role in the transfer of sugarcane varieties worldwide as it is not located in a sugarcane-growing area. It offers many advantages as regards varietal cleanliness. Many sugar producers and renowned research centres use this quarantine service. CIRAD uses new pathogen screening techniques, so the quality of plant material can be certified to meet importers' demand. This quarantine unit aims to supply certified disease-free plant material.

Disease elimination in sugarcane by tissue culture

In 1998, it was shown that meristem culture is efficient for eliminating *Sugarcane yellow leaf virus* (SCYLV) in sugarcane varieties infected with this pathogen. Material is systematically sanitized at CIRAD's quarantine unit in Montpellier to eliminate SCYLV in elite sugarcane varieties. In 2004, this cleaning process was conducted with the participation of CIRAD's research centre in Guadeloupe, where FR varieties to be quarantined were installed in tissue culture. In 2004, 47 SCYLV-infected varieties from Guadeloupe and 53 infected varieties from other geographical areas were thus cleaned by meristem culture; 130 varieties were thus hardened, potted and placed in quarantine glasshouses in Montpellier.

The presence of Asian varieties infected with *Sugarcane streak mosaic virus* (SCSMV) in quarantine also led us to increase our sugarcane cleaning operations via tissue culture. Three varieties from Sri Lanka were installed *in vitro* by meristem culture to generate a substantial number of tissue cultured plants free of this virus.

Varieties grown in quarantine glasshouses in the first and second years (international quarantine)

Two hundred and thirteen sugarcane varieties were grown in quarantine glasshouses in the first year (= first quarantine cycle) and 175 in the second year (= second quarantine cycle). The culture conditions in pots with drip irrigation have already been described[2]. The aim is to be able to produce and propagate disease-free sugarcane.

Sixty-nine varieties were released from quarantine during the 2003-2004 season: 17 varieties in Option 1 (international varieties), 21 varieties in Option 2 (FR varieties produced and supplied by CIRAD in Guadeloupe), 31 varieties in Option 3 (varieties supplied by the West Indies Central Sugar Cane Breeding Station, WICSCBS, in Barbados). Cuttings were mainly distributed in Africa (Burkina Faso, Cameroon, Congo, Mali, Uganda, Senegal, Sudan, Chad), the West Indies (Barbados, Guadeloupe, Martinique), the Mascarene Islands (Madagascar, Réunion), China, Indonesia and Papua New Guinea.

Disease diagnosis and detection

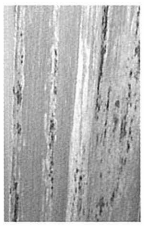
Pathogens sought

Varieties grown in first-year quarantine glasshouses were systematically screened in the laboratory to detect *Xanthomonas albilineans* (leaf scald), *Leifsonia xyli* subsp. *xyli* (ratoon stunting disease) and *Sugarcane yellow leaf virus* (SCYLV, yellow leaf). Depending on their origin, the varieties were also indexed for the following pathogens: *Sugarcane mosaic virus* (SCMV), *Sorghum mosaic virus* (SrMV), *Sugarcane streak mosaic virus* (SCSMV), *Sugarcane streak virus* (SSV), *Peanut clump virus* (PCV), *Fiji disease virus* (FDV), and phytoplasmas that cause white leaf and grassy shoot diseases. All varieties grown in second-year quarantine were screened again for SCYLV.

First quarantine cycle

In the first quarantine cycle, 213 varieties were tested in 2004. *Leifsonia xyli* subsp. *xyli* was detected in one variety (1 out of 48 tested varieties from Barbados). SCYLV was detected in 17 varieties (3 out of 48 varieties from Barbados, 10 out of 87 varieties from Guadeloupe, 1 out of 5 varieties from Réunion and 3 out of 10 varieties from Sudan). Note that 8 out of 131 varieties were not cleared of SCYLV via tissue culture and should now undergo a second round of meristem culture to eliminate this virus. Negative results were obtained in all tests to screen for phytoplasmas and viruses (FDV, PCV, SCMV, SrMV, SCSMV and SSV).

[2] Rott P., Bousquet J.F., Muller M., Chatenet M., 1997. La quarantaine de canne à sucre du CIRAD à Montpellier. Agriculture et développement 13: 22-28.



Peanut clump virus.
© D. Marion

Second quarantine cycle

In the second quarantine cycle glasshouses, 175 varieties were tested in 2004. SCYLV was detected in 9 varieties (2 out of 62 varieties from Guadeloupe, 3 out of 47 varieties from Barbados, 1 out of 10 varieties from Florida, 1 out of 18 varieties from the Philippines, 1 out of 12 varieties from Brazil and 1 variety from Malaysia). These varieties had tested negative for SCYLV in the first cycle. These results highlight the difficulties that can be encountered in screening for SCYLV, so these screening tests should be carried out several times during quarantine.

Adapting tests

In addition to these routine diagnostic initiatives, several screening tests were developed or tailored for laboratory use, especially to detect phytoplasmas and *Peanut clump virus* (PCV). For PCV, a technique involving the use of PCR primers described by a Belgian team[3], is reliable for detecting this virus, which is known to show high genetic diversity.

Integrated pest management

Sugarcane resistance to the spotted stemborer *Chilo sacchariphagus* in Réunion

S. Nibouche, R. Tibere, C. Lallemand

The sugarcane spotted stemborer, *Chilo sacchariphagus* (Lepidoptera, Crambidae), is a major pest in the Indian Ocean and Asian regions, and it was recently introduced in southern Africa. Identifying sources of resistance in current sugarcane collections and developing breeding tools could substantially enhance integrated management of this borer in sugarcane crops.

The performance of several resistance measurement criteria was assessed in a heritability study carried out in a CERF sugarcane variety trial in Réunion. The varieties were correctly classified on the basis of the early results (April). The performance of the simplified criterion "rate of damaged stalks" was similar to that of more complex criteria based on bored internode counts. The CERF collection of 456 international clones was screened: 13 potentially resistant clones and 19 potentially susceptible clones were identified (Figure 1). The level of susceptibility of these clones will have to be confirmed in tests with a statistical experimental design.

Feeding sites of stemborer larvae were characterized in surveys carried out in farmers' plots cropped with cv R579 (susceptible) or cv R570 (resistant). Only the first four larval instars were detected outside of the stalk. As of the first instar, the stemborers were distributed on the terminal leaves, leaf sheaths and stalks. They often advanced towards the stalk by boring at least one leaf sheath. They regularly pene-

[3] Bragard C., Delfosse P., Reddy A.S., Doucet D., Legrève A., Miller J.-S., Mayo M.A., 2002. RT-PCR for a broad detection of Pecluviruses. 5th International Symposium on Plant Viruses with Fungal Vectors, Zurich, July 2002.

trated the stalk at the base of the four internodes located under the terminal meristem, but they generally did not penetrate it via the axillary buds. Stemborer behaviour differed in the two varieties, suggesting that the resistance of cv R570 is partially expressed when leaf sheaths are perforated by the borers.

The next phases of this research will be to study resistance heritability in collaboration with CERF, to search for molecular markers, and to study resistance mechanisms in cv R570.

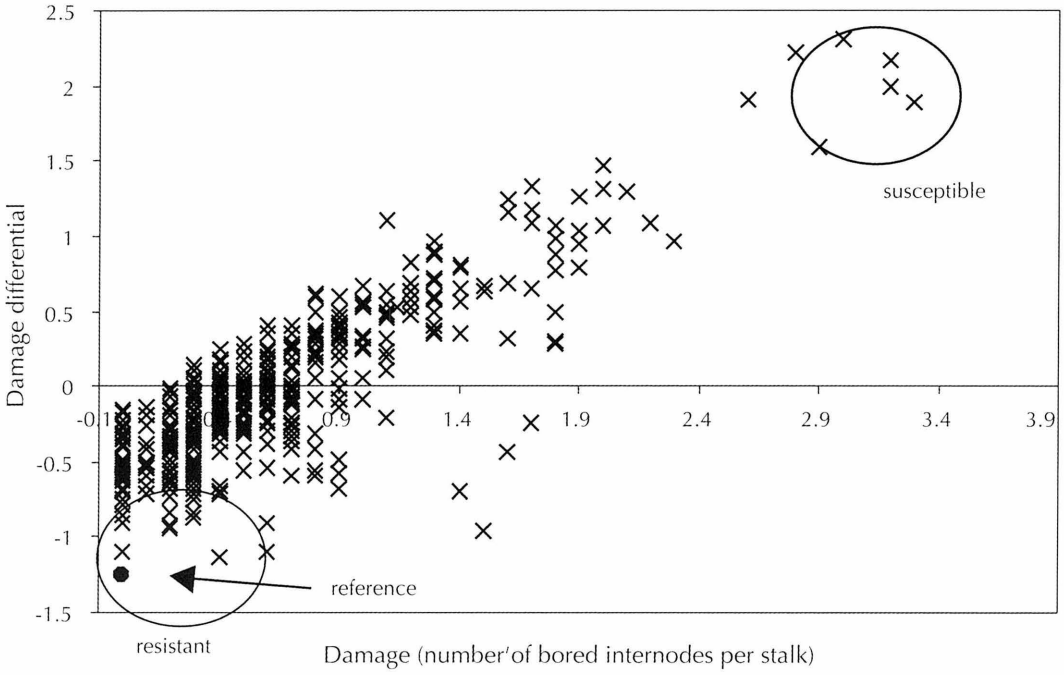


Figure 1. Stalk damage distribution in 456 clones from the CERF sugarcane collection (April 2004). The black dot indicates the clone (Kassoer) that was used as resistance reference to calculate susceptibility levels.

Note: The damage differential is the difference between the clone considered and the mean for the eight closest neighbours in the field. The units are identical on the x and y axes. A clone is assumed to be resistant if it has not been very damaged, and if it is less damaged than its neighbours.

Biological control of the sugarcane spotted stemborer *Chilo sacchariphagus* using *Trichogramma* parasitoids in Réunion

R. Goebel, E. Tabone (INRA), G. Barreault, M. Berling, H. Karimjee, P. Caplong (Fédération départementale des groupements de défense contre les organismes nuisibles aux cultures, FDGDON, Réunion)

The technique for biological control of the sugarcane spotted stemborer (*Chilo sacchariphagus*) involving use of the egg parasitoid *Trichogramma chilonis* has

now been validated through a research and development programme that has been under way since 2000 in partnership with FDGDON of Réunion and INRA (funding: General Council of Réunion and EU). In 2003, sugarcane yields were significantly higher, i.e. around + 36 t/ha in humid areas and + 15 t/ha in dry areas that are less exposed to this pest. Now that the efficacy of this biological control technique has been confirmed, the next step will be to transfer it to all sugarcane growers.

An optimization phase began in 2004 to simplify this complicated technique—200 parasitoids release points per ha, 17 releases over 4 months—and to reduce treatment costs. Several trials using susceptible cv R579 were set up by FDGDON in humid areas on the island where the pest pressure is highest (northeastern Réunion, Sainte-Marie), with the following objectives: to reduce the release period; to reduce the dose of parasitoids released; to reduce the density of release points; and to evaluate the technique under irrigated cropping conditions (previous tests were only conducted under dry cropping conditions at Sainte-Marie).

At the request of the General Council of Réunion, a pre-extension treatment was carried out in 2004 on a 10 ha area, and all parasitoids were released on plant cane since it is more damaged by the stemborer than ratoon cane.

The final results of all of these experiments will be available after the sugarcane harvest in 2005, so that improvements can be made in 2006.

Surveys on *Eldana saccharina* stemborer damage in small-scale farms in Kwazulu-Natal (South Africa)

R. Goebel, M. Way (South African Sugar Research Institute, SASRI)

Successful bilateral cooperation between Réunion and South Africa

The main aim of the 3-year (2002-2004) bilateral cooperation project involving the Kwazulu-Natal region in South Africa and Réunion, with funding from the Regional Council of Réunion, was to create a dynamic framework for research on small-scale sugarcane farms (mainly in South Africa) with the help of students from both regions. This overall research was essential to determine the impact of the *Eldana saccharina* stemborer (Lepidoptera, Pyralidae) on the South African sugar industry and to gain insight into ecological and agricultural parameters influencing these infestations. A substantial survey database managed by SASRI was thus analysed over a 3-year period to determine infestation trends in each region and to pinpoint specific issues requiring further investigation.

Sustained training and data exchange

In 2004, activities were focused on trainee supervision, training and data exchange between partners from South Africa and Réunion. Since the beginning of the project, eight students from Réunion have attended training sessions at SASRI (Master's, engineering, senior technician), representing a total of 24 months of direct contributions to research. In 2003, a South African student (PhD) was hosted by the crop protection team (JRU Plant Communities and Biological Invaders in Tropical Environments) for a research visit at Saint-Pierre in Réunion.

In 2004, two students (engineering and senior technician) conducted surveys on South African sugarcane farms. The results obtained by all pest and disease control teams associated with sugar factories in all sugarcane-growing regions of Kwazulu-Natal were taken into account (Figure 2).

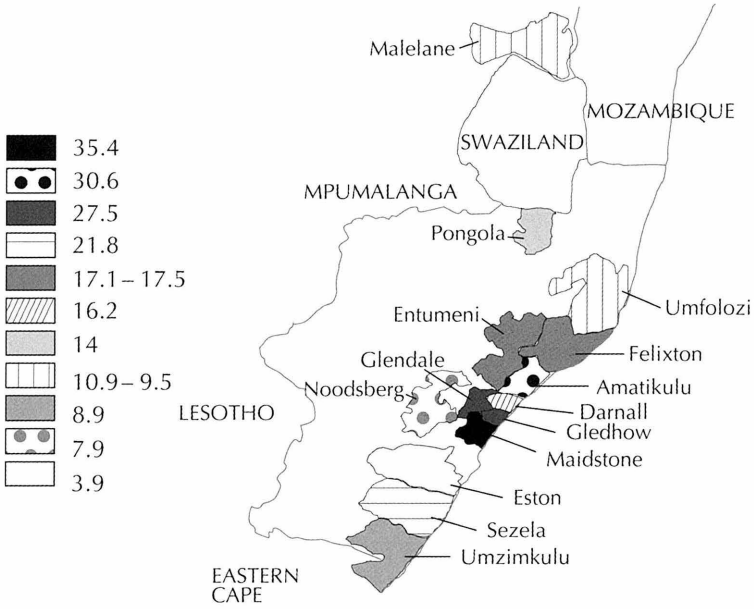


Figure 2. *Eldana saccharina* infestation levels (% damaged stalks) in major sugarcane-growing regions (2003). CV = 47.6%, F-value = 1430.0, P (probability) < 0.0001. Sugarcane-growing regions of the same colour are not significantly different (P > 0.05, Student-Newmans Keuls test, SAS Institute).

Technical and scientific results

Eldana saccharina infestations were observed in most sugarcane-growing areas of Kwazulu-Natal, but the mean damage levels varied markedly between regions: from 3.9% damaged stalks at Eston to as much as 35.4% at Maidston (Figure 2). This situation is not yet catastrophic, but the damage level is steadily rising each year. From a geographical standpoint, stemborer boring levels decrease with the distance from the coast, which is in line with the change in ecological conditions (inland the elevation is higher and temperatures are lower, e.g. in the Eston region). GIS will be used in the future to assess infestation levels in terms of agricultural and environmental parameters.

Maps of infestation risk areas will be drawn up on a yearly basis to help the pest and disease control teams to target areas for survey operations. Infestation levels can be converted into economic injury levels, thus providing a useful decision-support tool for sugar industry stakeholders. In this way, it is possible to pinpoint areas where the economic damage is equivalent to or higher than the cost of a control programme, e.g. this level was 28% damaged stalks in 2003.

The survey results confirmed the low level of stemborer damage on small sugarcane farms in comparison to commercial plantations. In the most affected areas, the percentage of damaged stalks was two- to three-fold higher in large-scale plantations (Figure 2). One explanation for this trend is that nitrogen fertilization

could have a high impact on infestations. Commercial plantations with high nitrogen inputs (over 130 kg/ha/year) were faced with the most severe stemborer infestations. Fertilizer overdosages is a problem that SASRI's development engineers have pointed out, so notices will now be systematically disseminated to growers instructing them to strictly comply with recommended dosages.

The varied landscape and biodiversity (fauna and flora) on small-scale sugarcane plantations in South Africa—in stark contrast with commercial plantations—seems to be conducive to the presence of predators that regulate stemborer populations and keep them from causing serious damage.

Other aggravating factors have also been noted on large plantations, such as the use of susceptible varieties or late sugarcane harvesting, i.e. so-called carryover (Figure 3). Harvesting carryover crops after 12 months (13-18 months depending on the region) is done to boost sugar yields, but these gains may be nullified by serious stemborer outbreaks, which are known to intensify as the cane crop ages. Moreover, carryover crop fields host substantial stemborer populations that subsequently contaminate neighbouring fields. The sugar industry should warn commercial growers as to this problem.

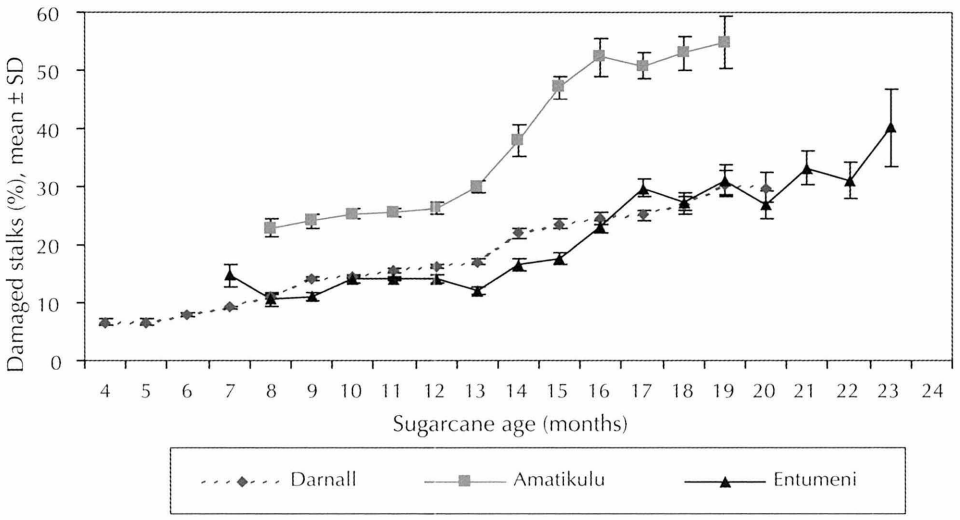


Figure 3. *Eldana saccharina* infestation patterns (% damaged stalks) according to the age of the crop in three sugarcane-growing areas in Kwazulu-Natal.

Biodiversity in crop fields under a banana-sugarcane-banana rotation scheme in Guadeloupe

B. Vercambre, J.H. Daugrois, F. Caray

Biodiversity and biological evolution patterns were studied at Capesterre-Belle-Eau, Guadeloupe, in fields under three cropping systems, i.e. monocropped banana, monocropped sugarcane, and a banana-sugarcane-banana rotation. Biolog® plates were used to characterize the functional intensity of the soil microflora, and arthropods were trapped on the ground or on glue strips to determine

the arthropod diversity patterns. The Shannon index and PCA were used for the data analysis.

The biodiversity features were found to differ in the two monocrop situations—biodiversity was very low with monocropped banana, whereas it was higher and more balanced in the monocropped sugarcane fields. In the first and second years with banana after sugarcane, the arthropod biodiversity was close to that noted for monocropped banana, but the soil microfauna level differed. In the rotation scheme, sugarcane seemed to promote higher biodiversity in the soil under the subsequent banana crop, but the biodiversity level was still not as high as that noted in monocropped sugarcane fields. The observed gain in soil microflora quantity and diversity in banana fields following a sugarcane crop lasts for several banana crop cycles. This could explain the low level of nematode damage to banana crops noted after sugarcane. However, the observed increase in microfauna biodiversity on the soil surface (arthropods) is shortlived and closely depends on the prevailing crop type. This indicates that in banana crop fields it is hard to obtain the same level of biodiversity and balance as in a sugarcane crop field. In the second year after a banana crop, the biodiversity is gradually reestablished in sugarcane fields, as indicated by the reduction in stemborer damage in 2003.

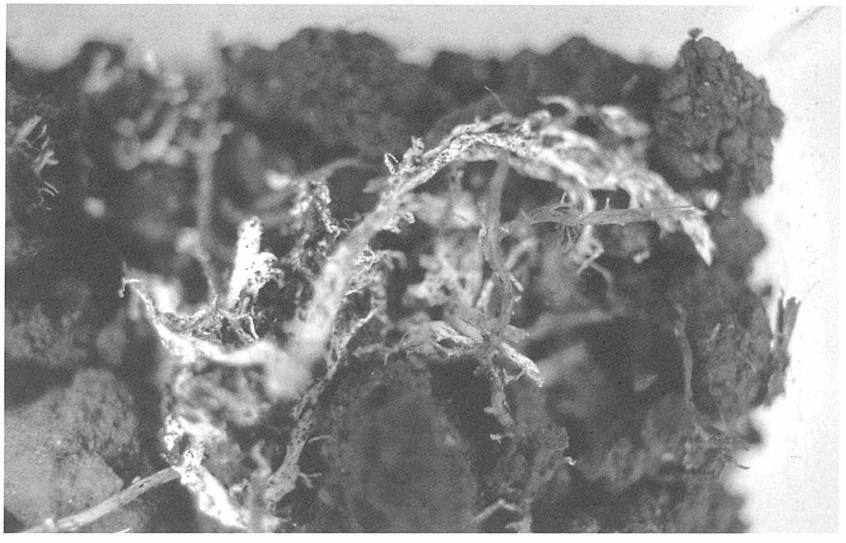
Biological control of the sugarcane white grub *Hoplochelus marginalis* using *Beauveria brongniartii* in Réunion

B. Vercambre, M. Fouillaud, F. Chiroleu, A. Rolet, S. Georger, D. Dedieu

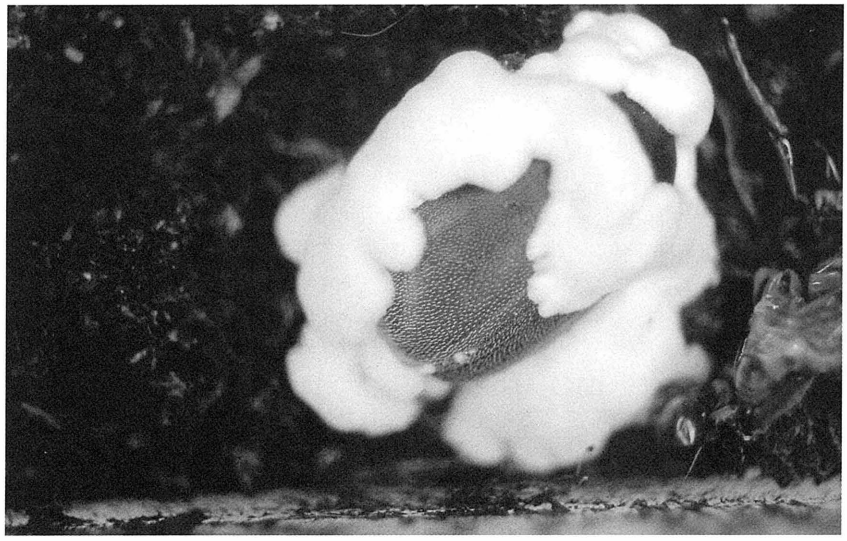
Evolution of populations of the white grub and the fungus

Surveys carried out by FDGDON in Réunion since 2001 to assess infestation patterns of *Hoplochelus marginalis* (Coleoptera, Melolonthinae) larva have revealed a surprisingly stable situation: in 2004, the mean density was 0.3 white grubs/sugarcane stool, with an economic threshold of 4 white grubs/stool in dry areas, but the levels have still remained somewhat high in the Sud region (Saint-Louis and Saint-Pierre). The mean rate of infection of larva at the final moult (L3 stage) by the fungus *Beauveria brongniartii* is around 40% in Réunion (data based on checks in the field and in the quarantine laboratories at the Université de La Réunion).

According to theoretical projections, based on white grub biological parameters (number of eggs per female, sex ratio, etc.), the situation is now stable since 70-90% of the white grub population has disappeared (or did



The *Beauveria brongniartii* fungus on roots.
© B. Vercambre



Adult white grub attacked by *Beauveria brongniartii*.
© B. Vercambre

not hatch), in addition to L3 grubs attacked at the end of this cycle. Two complementary phenomena could be involved. First, the other biological stages of the insect are infected by the fungus. On a plot monitored at Saint-Louis (380 m elevation) that had never undergone biological treatment, 18.2% of nymphs were found to be infected at the end of November and 16.7% of adults were infected in the first 10 days of December. The white grub density then dropped by 60% between June and December (from 2.3 to 0.9 live white grubs/stool). Finally, the biotic potential of females seems to have declined as compared to that measured after the introduction of white grubs on the island in 1973.

Assessment of the pathogenicity of Betel®

Two granule samples were collected in bags containing Betel® (commercial brand of *Beauveria brongniartii*) selected randomly from the main suppliers in Réunion—the shelflife of this product is 4-5 months. The tests were carried out on white grub larva and adults from July to December. The following results were obtained: excellent pathogenicity for the sample collected from Saint-André (batch P0404, 90% mycosis at 30 days on larvae and adults), fair pathogenicity for the sample collected from Saint-Louis (batch P0403, 50% mycosis at 30 days on larvae).

Loss of white grub vitality

Very precise study conditions are required to get reliable data on a potential decline in white grub populations in Réunion. The egg-laying potential, which could be considered as a vitality loss indicator for the species, can only be evaluated in female grubs that have completed their ovarian development (around 3-4 weeks after emergence) without having laid any eggs. This state occurs just at the time of the first mating, which is in turn linked with the rainfall conditions. Adults begin emerging from the soil in early November and ovarian maturity can only be reached around late November-early December. During this period, dissec-

tions of 61 couples collected at Saint-Pierre and Saint-Leu revealed a mean fertility potential of 43 eggs/female, which represents a reduction of around 20% relative to the potential assessed just after white grubs had been introduced in Réunion in 1973 (the potential at that time was 60 eggs/female). At Saint-Louis, the mean number of eggs/female was 30-34 in early December in a sample of 14 females (i.e. a reduction of around 30%). A larger scale study should be conducted to strengthen these quite fragmented preliminary observations.

Scale insects—emerging pests in Réunion

B. Vercambre, B. Hostachy (Service de la protection des végétaux, SPV, Réunion), V. Lebourgeois

The establishment of sugarcane farms in new irrigated areas in western Réunion should be closely monitored in order to detect emerging pest and disease problems. In 2004, a survey initiated by the crop protection service highlighted the presence of sucking insects: three scale insects were noted, including *Aulacaspis tegalensis*, which induced a 24% yield loss in 2003 in the surveyed sugarcane plot. This infestation was characterized by satellite imaging (Figure 4). In 2004, the scale insect infestation level was lower because systematic pesticide treatments had been halted and due to the rise in beneficial organisms (ladybugs, parasitoids, etc.).

Remote sensing techniques are now perfected for detecting scale insect damage, which is clearly visible on foliage. A report could thus be drawn up on the situation on the basis of the results of an island-wide survey in Réunion.

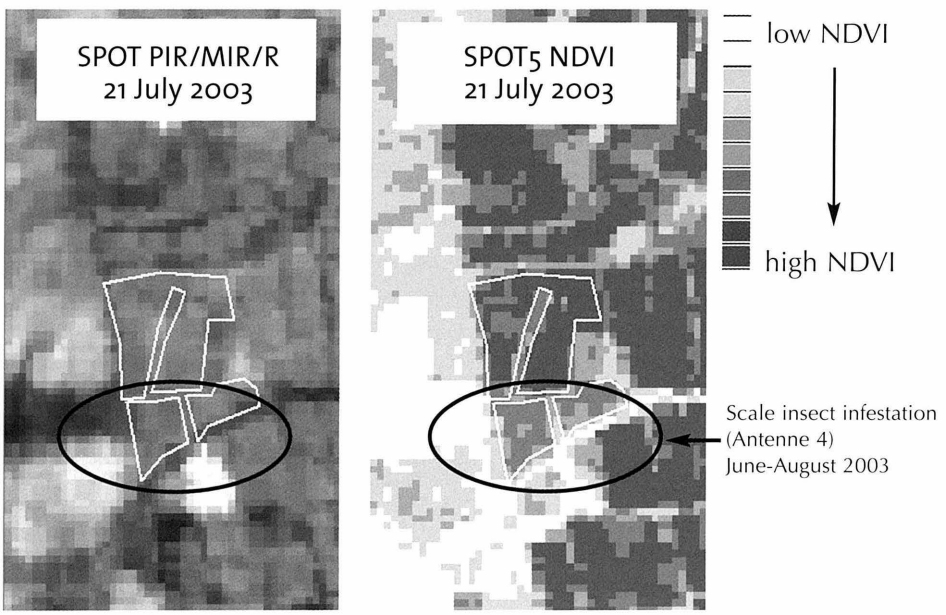
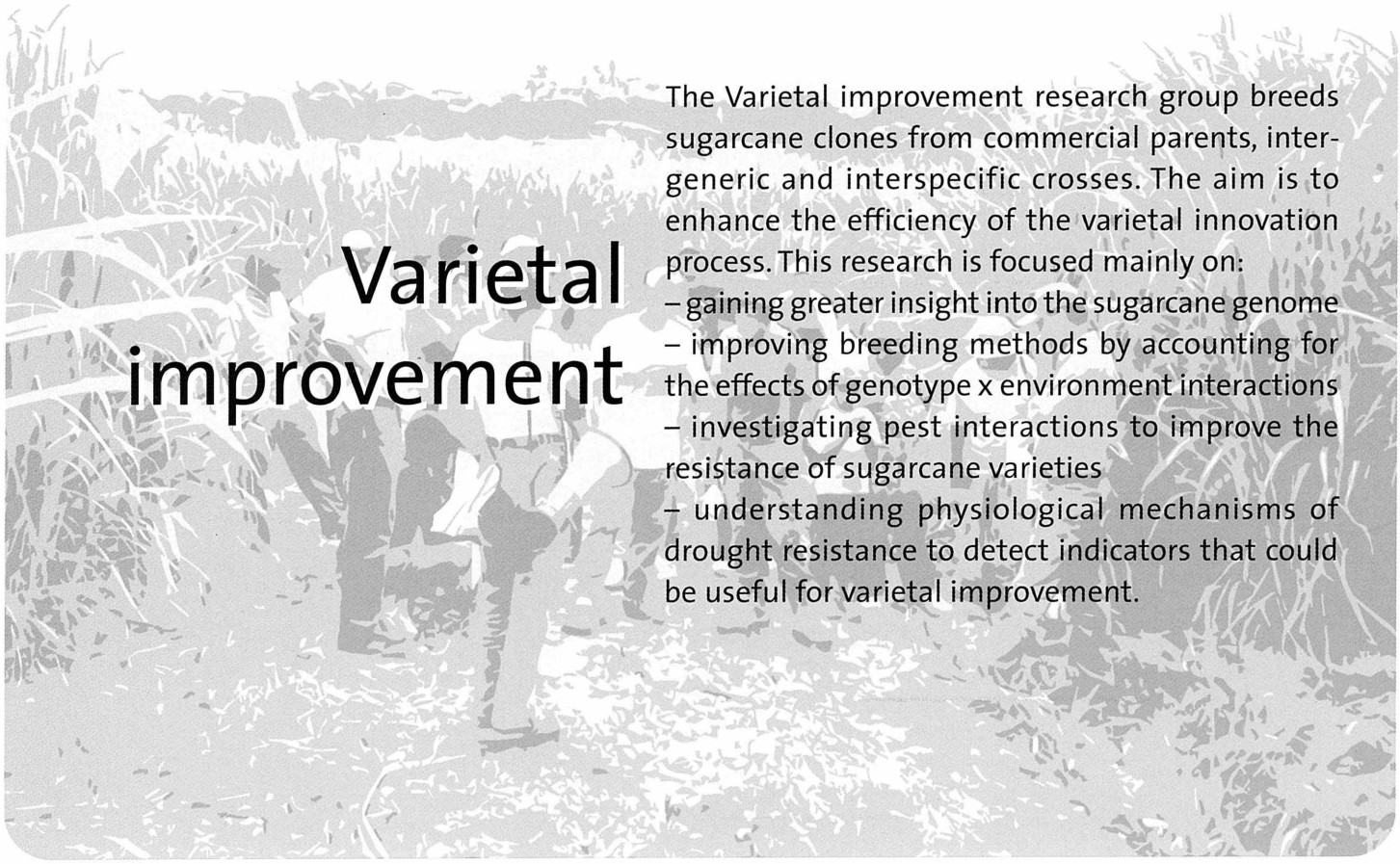


Figure 4. Satellite images of scale insect infestations in newly irrigated areas in Réunion (Saint-Gilles, Antenne 4). Spectral analysis using NDVI (normalized difference vegetation index). Images processed by V. Lebourgeois (SUCRETTE project, 2004).



Varietal improvement

The Varietal improvement research group breeds sugarcane clones from commercial parents, inter-generic and interspecific crosses. The aim is to enhance the efficiency of the varietal innovation process. This research is focused mainly on:
– gaining greater insight into the sugarcane genome
– improving breeding methods by accounting for the effects of genotype x environment interactions
– investigating pest interactions to improve the resistance of sugarcane varieties
– understanding physiological mechanisms of drought resistance to detect indicators that could be useful for varietal improvement.

The Varietal improvement research group is based in Guadeloupe and coordinated by Philippe Oriol.

CIRAD, Sugarcane Programme, 2004

Sugarcane preselection and breeding

D. Roques, L. Toubi, G. Gelabale, M. Cadet, G. Algou

Germplasm management

Genetic diversity in the sugarcane germplasm collection was further enhanced through the introduction of 47 new clones from abroad (Table 1). The collection currently consists of more than 1 300 genotypes which are available for the varietal improvement programme: commercial hybrids, F1 hybrids, wild and related species. The cryopreservation protocol was adapted to laboratory conditions for long-term conservation of sugarcane germplasm.

Table 1. Origin of the 47 foreign sugarcane varieties introduced in the CIRAD sugarcane germplasm collection in 2004 (Guadeloupe).

Origin	Code (preceding the variety name)	Number
Bangladesh	ISD	2
Barbados	B	11
Belize	BBZ	9
Brazil	RB/SP	3
Cuba	C	2
Dominican Republic	BR	6
Florida	CP	2
French Guiana	DB	2
Malaysia	TC	2
Porto Rico	PR	1
Sudan	KN	3
Taiwan	ROC	1
Trinidad	BT	3

Crossing campaign

One hundred and ninety-seven hybridizations were performed during the sugarcane crossing season, i.e. from October to December (Table 2). After selection, crossing in the 2004 season gave rise to the FR 2007 series. These hybridizations were performed in more suitable renovated breeding facilities, so the process is now more efficient and requires less labour.

Table 2. The 197 hybridizations performed in Guadeloupe in 2004.

Type of crossing	Number
Selfing	6
Bi-parental	94
Poly-crossing	77
Open pollination	20

Preselection trials

Table 3 summarises the preselection trials conducted at the Roujol research station.

Aims, facilities, activities

The aim of sugarcane varietal improvement is to breed and disseminate new efficient varieties that are adapted to the agricultural and environmental conditions of our partners in the French overseas departments and abroad.

The research facilities (genetic resources, hybridizations, early selection tests) are located in Guadeloupe, in relation with breeding teams based in different sugarcane-growing areas.
The activities are carried out in close collaboration with CIRAD's BIOTROP laboratory (genomic studies) and crop protection research teams (quarantine, varietal resistance).

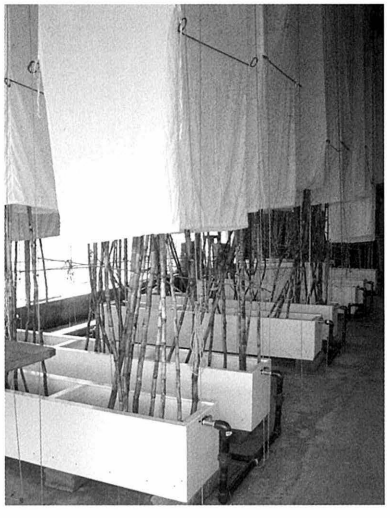
Key features of the activities

- Strengthening research on sugarcane varietal improvement topics, including specific initiatives concerning rainfed sugarcane cropping in very dry regions.
- Coordination of research teams, including scientific and development partners.
- Active participation in regional sugarcane networks (WISBEN in the West Indies, network in West and Central Africa).

Table 3. Preselection stages in 2004.

Series	Stage	Number of clones evaluated	Subsequent stages or number of clones selected
FR 2006	Stage 1	4 680 seedlings	Family selection (in May 2005)
FR 2005		7 540 seedlings	Clonal selection (in May 2005)
FR 2004		7 150 seedlings	892 clones selected (in July 2005)
FR 2004	Stage 2	892 clones	To be selected in April 2005
FR 2003		610 clones	127 clones selected (May 2004)
FR 2003	Stage 3	127 clones	To be selected in April 2005
FR 2002		72 clones	20 clones propagated for Stage 4
FR 2002	Sanitization before dissemination		*In vitro* meristem culture to eliminate *Sugarcane yellow leaf virus* (SCYLV)
FR 2001			
FR 2001	Dissemination		65 preselected clones dispatched for quarantine in Montpellier
FR 2000			

Stage 1



Hybridization setup in Guadeloupe. © D. Roques

FR 2006 series: progenies from 100 families (i.e. 4 680 seedlings) that were bred during the 2003 hybridization campaign were tested in July 2004. They are to be evaluated in April-May 2005.

FR 2005 series: 15 families were selected on the basis of the results of tests on progeny of 100 families from the 2002 hybridization campaign. Fuzz from these crosses was sown and gave rise to 7 540 seedlings. These seedlings were planted in Stage 1 (one stool) in August 2004. They are to be selected in May-June 2005.

Stage 2

FR 2004 series: 12% of this series, i.e. 892 clones, were selected and assessed in Stage 2 in June 2004. They are to be further evaluated in April 2005.

FR 2003 series: 21% of this series, i.e. 127 clones, were selected in May 2004.

Stage 3: early smut test

FR 2003 series: 127 clones were assessed in Stage 3 after inoculation of cuttings by soaking in a smut spore solution. They are to be selected in April 2005.

The smut spore inoculation procedure was introduced at this selection stage in 2004. The smut susceptibility results are thus obtained at the beginning of Stage 3, i.e. 2 years earlier than in the tests used previously (which were conducted on clones selected at the end of Stage 3). With the new procedure, clones can now be selected according to smut resistance, in addition to agricultural criteria, before moving on to Stage 4. This information is therefore available prior to dispatching the clones for quarantine.

FR 2002 series: 72 clones passed screening tests for the first three selection stages. They are currently being placed in *in vitro* meristem culture for elimination of the *Sugarcane yellow leaf virus* (SCYLV).

FR 2001 series: the preselection evaluations were completed in 2003. 57 clones have been sanitized by *in vitro* meristem culture to eliminate SCYLV. Some of these clones were sent to the CIRAD quarantine unit in the form of micropropagated plantlets and the other clones are to be sent in February 2005.

Dissemination of preselected clones

FR 2000 series: the clones were dispatched to the CIRAD quarantine unit, in February 2004, in the form of micropropagated plantlets after sanitization by in vitro meristem culture.

Varietal selection in Guadeloupe

P. Oriol, S. Mayo, V. Virapin, E. Nudol, J.C. Efile, E. Catan, M. Carbel, S. Cayeux

Selection trials

The selection criteria are sugarcane yield, extractible sucrose content, disease resistance and specific features such as vigour, mechanical harvesting suitability and drought resistance.

The selection programme takes the adaptation of varieties to the two most different soil-climate areas in Guadeloupe into account. A network of precommercial experiments with farmers' participation was set up to check the performances of new varieties disseminated to commercial plantations in different sugarcane-growing areas (Table 4).

Nine new promising varieties were selected because their yields were equivalent to or higher than those of currently cropped control varieties. These varieties were being propagated in 2004 to be used subsequently in precommercial trials in the concerned areas in 2005. This includes the following varieties:
– Basse-Terre: B88 804, B91 948, BT83 339, FR94 129, FR94 218 and FR94 295
– Grande-Terre and Marie-Galante: B85 764, , FR95 285 and FR99 349.

Table 4. Participative precommercial trials conducted in 2004.

Location	Cropping cycle	Number of trials	Varieties tested
Northern Basse-Terre	1st ratoon	3	B 86 89, FR 83 2034, FR 83 2035, FR 90 306, FR 90 840
Southern Basse-Terre	Plant cane	1	B 86 89, FR 90 306
Grande-Terre	1st ratoon	3	FR 83 2034, FR 83 2035, FR 88 196, FR 89 423, FR 89 746
Marie-Galante	Plant cane	2	FR 83 2034, FR 88 196, FR 89 423, FR 89 746

Varieties adapted to field conditions

In Guadeloupe, the aim of sugarcane varietal selection is to breed high yielding varieties that are adapted to cropping conditions used by the sugarcane and rum industries.
The regional selection stages are conducted on farmers' land. Partnerships have been established with farmers and agricultural organizations (Gardel's estate, SCEA-Aiguebel, Convenance agricultural school), as well as with the INRA experimental unit to promote participative selection.

Field extension session in Guadeloupe.
© P. Oriol

The sugarcane varietal selection scheme will meet planters' demand by taking into greater account adaptations to areas with a high water deficit (70% of the area under sugarcane when including Marie-Galante) and the specific area south of Basse-Terre, where sugarcane is cropped in rotations with bananas. The precommercial trials will also be undertaken in the four sugarcane-growing areas.

OTHER TOPICS

- Involvement with CRB (Centre de ressources biologiques) under discussion.
- Study on ecophysiological mechanisms of a plant's adaptation to water stress, in collaboration with INRA and the Université des Antilles et de la Guyane, with the aim of integrating these traits in varietal improvement programmes.
- Development of Améliocas, i.e. a relational database to enhance varietal improvement management, with the support of the Biostatistics team of the CIRAD Annual Crops Department.

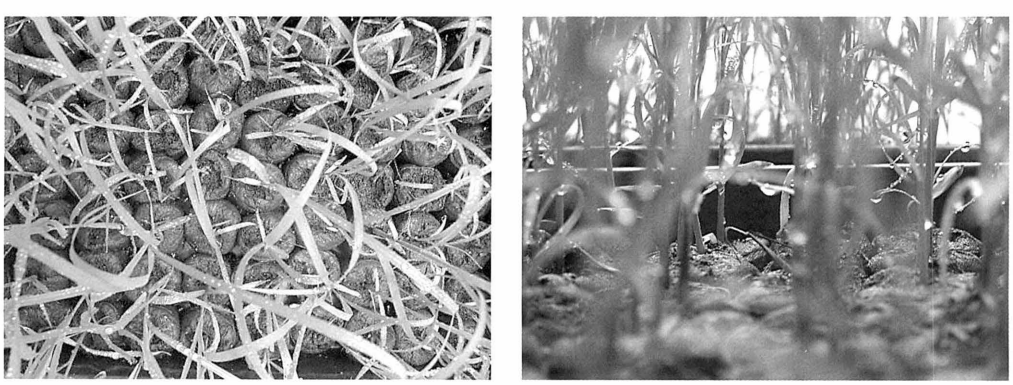
Study of family x environment interactions

D. ROQUES, L. TOUBI, G. GELABALE, M. CADET, G. ALGOU

Family x environment interactions have been investigated in Guadeloupe (Grande-Terre and Basse-Terre) since 2003 under highly differing soil-climate conditions. The aim of this study is to determine whether it would be relevant to integrate this factor in the regional sugarcane breeding programme.

This study is being carried out with the INRA partnership. Two trials were set up in July 2003 at the INRA research station at Godet in Grande-Terre and at CIRAD's Roujol research station in Basse-Terre. The results highlighted:
– a highly significant site effect and family effect on all sugarcane yield components (Brix, stalk number, diameter and height)
– a significant site x family interaction on all sugarcane yield components.

In conclusion, sugarcane varieties rank differently for performance under different soil-climate conditions. These results confirmed the benefits of diversifying selection sites at an early selection stage in Guadeloupe.



Glasshouse experiments in Guadeloupe set up to study pathogenicity variability in *X. albilineans*, the causal agent of sugarcane leaf scald.
© P. Champoiseau

Production of disease-free plants

D. Roques, J. Sapotilles, C. Guiougou, M.C. Planchet, P. Navis, A. Joseph

In 2004, eight sugarcane varieties were propagated by CIRAD's *in vitro* culture laboratory to meet the demand for nursery plants from CTICS—this involved around 25 500 micropropagated plantlets (Table 5). Four promising varieties (FR 88 196, FR 89 423, FR 89 746, B 86 89) were also propagated by *in vitro* meristem culture. Finally, 1 595 micropropagated plantlets were produced for the purposes of the following research activities:
– *in vitro* propagation and hardening of 1 500 micropropagated plantlets (cv B 80 08) to reduce the effects of between-family competition in progeny tests
– elimination of the *Sugarcane yellow leaf virus* (SCYLV) in FR 2001 (23 clones) and FR 2002 (72 clones) by *in vitro* meristem culture.

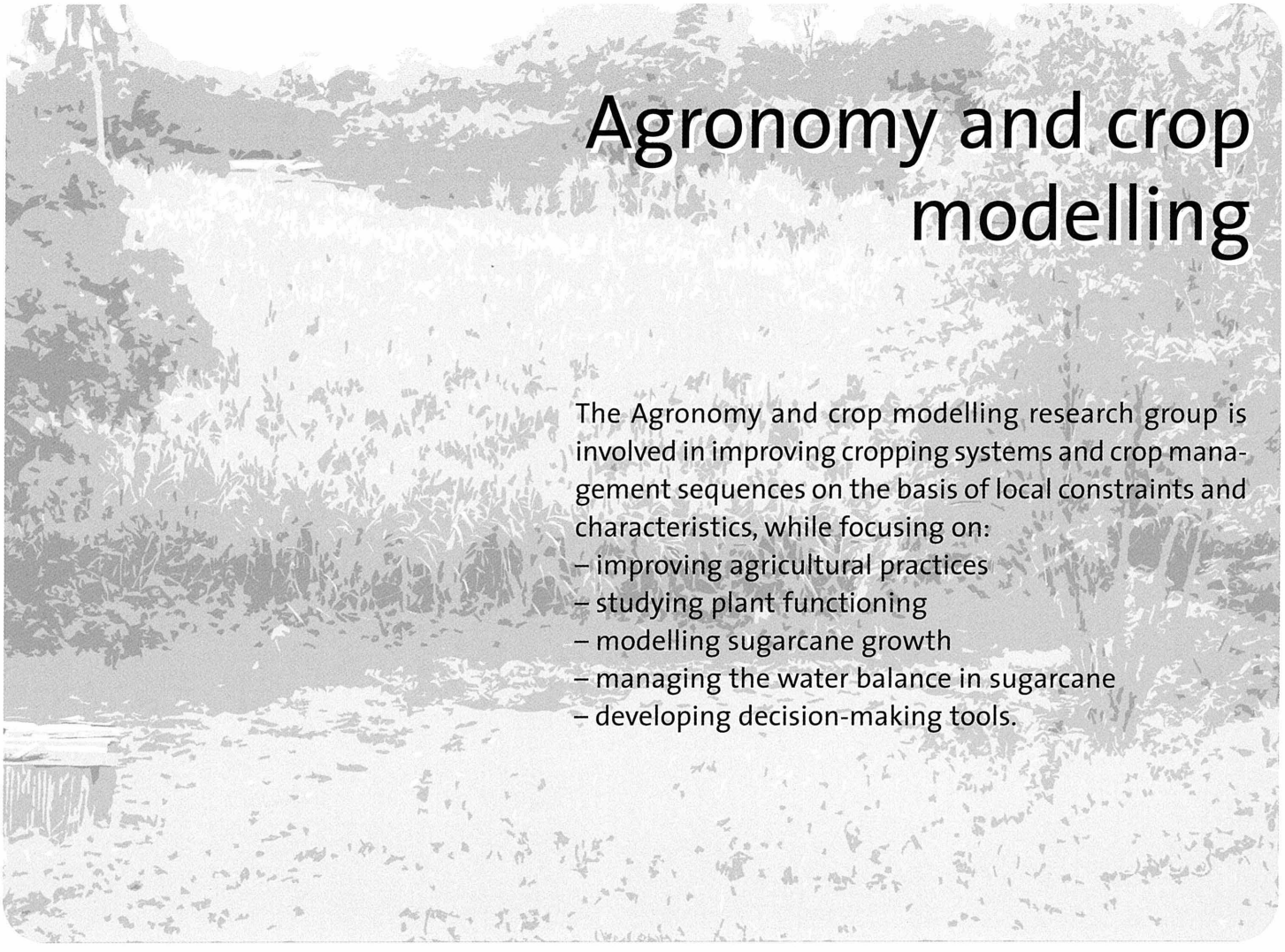
Table 5. The eight disease-free sugarcane varieties propagated *in vitro* for stock-plant nurseries in Guadeloupe in 2004.

Variety	Number of micropropagated plantlets
R 570	4 938
R 579	3 732
B 80 689	9 510
B 69 379	500
B 59 92	1 793
B 80 08	2 500
B 69 566	2 027
B 82 139	500
Total	25 500

Nurseries in Guadeloupe

The current nursery scheme was recommended by the local crop protection service, CIRAD and CTICS in 1987 to control serious sugarcane diseases that were spreading, especially leaf scald. Plants grown in the nurseries are derived from healthy micropropagated plant material. Cuttings are taken from these nursery plants to supply all annual crop plantations in Guadeloupe and Marie-Galante (2 500 to 3 000 ha).

In order to obtain the best possible sanitized planting material (varietal purity, healthiness, emergence vigour), heat-treated disease-free plants are used as starting material for micropropagation.
This starting material is then mass-propagated in the Roujol *in vitro* culture laboratory. After a hardening period of around 1 month, the micropropagated plantlets are planted in the field in the first nursery stage (stock-plant nursery).



Agronomy and crop modelling

The Agronomy and crop modelling research group is involved in improving cropping systems and crop management sequences on the basis of local constraints and characteristics, while focusing on:
– improving agricultural practices
– studying plant functioning
– modelling sugarcane growth
– managing the water balance in sugarcane
– developing decision-making tools.

The Agronomy and crop modelling research projects are coordinated by Denis Pouzet.

CIRAD, Sugarcane Programme, 2004

Cropping sugarcane in highland regions of Réunion: a worthwhile venture

C. Poser, A. Velle

The highland region of Réunion offers considerable potential for expanding the sugarcane-growing area. Highland sugarcane cropping accounts for 26% of the total area under sugarcane on the island, with elevations ranging from 200 m in the east to 600 m in the west. Current sugarcane varieties and cropping practices are, however, ill-adapted to this natural environment. Temperatures and solar radiation are low (30% lower than in coastal areas), and rainfall is irregular but still higher than along the coasts. This land is isolated partially because of the steep slopes—the fields are hard to reach and mechanised cultivation is sometimes impossible.

Crop yields are low because of these constraints (18% of the sugarcane production of Réunion), but this production is essential for the industry and the economic balance of farms in the highland region. The current goal is thus to expand the highland sugarcane-growing area and develop cropping systems that are tailored to the specific climatic conditions of this area. The research is mainly focused on breeding varieties adapted to highland conditions, narrow interrow spacing and extending the cycle between two crops.

Sugarcane cropped in highland regions of Réunion.
© D. Pouzet

CIRAD has thus been carrying out a study on narrowing the interrow spacing in sugarcane crop fields over the last 8 years. Growers in highland areas have been using this technique on an empirical basis. The test results confirmed that the technique is very effective for controlling weeds and increasing sugarcane yields. Yields were increased by 7.8% by narrowing the interrow spacing from 1.6 m to 1.1 m in the eastern highlands, and by 12.2% by narrowing the spacing from 1.5 m to 1.2 m in the western highlands. This modification also results in substantial labour and herbicide savings.

Another way of controlling weeds in the highlands is to increase the between-harvest cycle from the standard 12 months to 24 months. This reduces the period during which weeds compete with the open canopy. The peak vegetation period is longer and sugar yields are higher (increasing from 9 to 25%), but there are still a few risks to consider (lodging, fire, rats, transportation, etc.).

Fertilization recommendations in Réunion

D. Pouzet, A. Velle, H. Lombard, P.F. Chabalier, G. Vignais, P. Legier

The CIRAD soil analysis laboratory

The fertilization recommendations of the CIRAD soil analysis laboratory in Réunion were improved by reprogramming the expert system, by soil-unit georeferencing, and by taking the production potential of sugarcane plots (mineral dilution curves) and farmers' practices (residue management practices, effluent use, etc.) into account.

A GIS was developed for soil identification using SAS® and MapInfo® software. It provides three levels of information for each sampling location grid cell (500 m^2):
– soil units identified from morphopedological classifications at 1/50 000 resolution
– the total area of each unit
– the location of each grid cell.

The expert system of the soil analysis laboratory was reprogrammed because the former FoxPro® version was not compatible with the current computer environment. The new Visual Basic® version will include the soil-identification GIS and a module that will generate the soil sample classification probabilities according to different analyses.

Agronomic analysis tool

The MOSICAS growth model can be used as a tool to assess agronomic potentials in farmers' fields, thus highlighting the progress required to achieve optimal production in these fields. This work was carried out with the support of the Decision Support and Biostatistics team of CIRAD's Annual Crops department.

Logging data in the field for agronomic analysis in Réunion.
© P. F. Chabalier

A study of differences between actual and simulated yields pooling around 500 verified pairs of data from three farms (one irrigated) was finalised (Figure 1). The model provided a good idea of the production potential of cv R570, with or without water stress and for a crop with a between-harvest cycle of not more than 14-15 months. The model indicated better yields for cv R570 than for cv R579. The simulations differed from the actual results for longer cropping periods and when there was a higher number of ratoons. The results did not fit when the elevation varied. Differences were not sensitive to the crop year factor. The model could thus be used as an agronomic analysis support tool for cv R570 cropped in lowland areas with a cycle of less than 15 months.

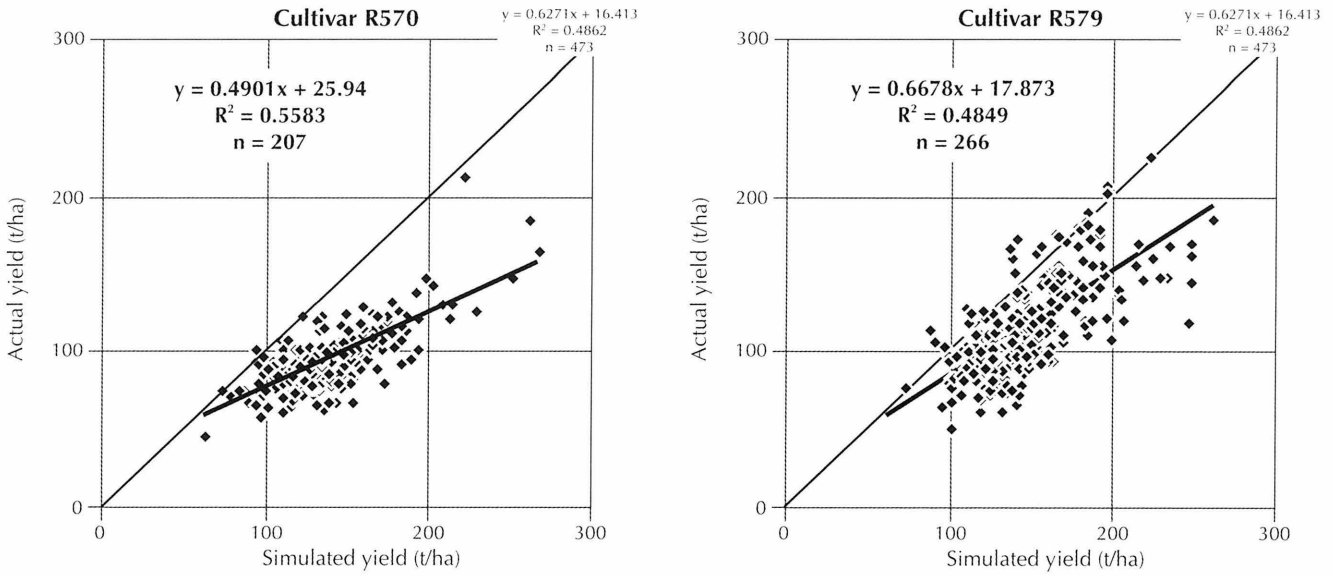


Figure 1. Actual and simulated yields for cvs R570 and R579 (millable cane, t/ha).

Improving sugarcane cropping systems in Guadeloupe

C. Poser, A. Ndemapou

Sugarcane yields are much lower than the potential in northern Grande-Terre, Guadeloupe, around the towns of Petit Canal, Port Louis and Anse Bertrand. CIRAD, in collaboration with SICADEG (Société d'intérêt collectif agricole et de développement économique de la Guadeloupe) and members, conducted a survey to explain these yield differences and propose solutions.

Rainfall in this region is low, variable from year to year and highly localised. Currently, 12% of the sugarcane cropping area is irrigated. The shallow soils are generally compacted in the interrows, which can become a constraint during drought periods.

The mean sugarcane yield was found to be 57 t/ha (range 10-86 t/ha) in the 31 plots monitored on 18 farms. The sugar content was closely dependent on the harvesting method (mechanical cutting, burning) and the harvest period (rainfall) more than on the cropping practices.

The survey results indicated that three main factors could explain the yield variations:
– cane planted too late and under relatively poor conditions, e.g. no irrigation on many plots, soil analyses very seldom carried out prior to planting, decompaction between rows, generally no soil amendments, distances between planting furrows greater than recommended, cuttings taken from cane plants more

Planting excessively long cuttings, which hampers shoot-tip growth.
© C. Poser

Poor compacted soil in northern Grande-Terre, Guadeloupe.
© C. Poser

than 10 months old, planting of excessively long cuttings and not quickly covering them with soil, with very little replacement of missing plants
– poor weed management on plots that are neglected because of poor initial growth, postponement of harvesting until the next season, no irrigation possibilities, or a lack of maintenance on irrigated highly diversified farms
– poor water management in irrigated fields, with available supplies often used for supplementary irrigation. No Théresa probe, highly variable water flow rates in fields, heterogeneous instantaneous water supplies sometimes incompatible with the soil type.

The following solutions were proposed:
– to boost the awareness of agricultural contractors on the importance of complying with specifications, especially for planting operations
– to improve cropping cycle adjustment (planting date)
– to boost the industry's capacity to overcome constraints associated with planting early drought-tolerant varieties in shallow soils
– to ensure good weed control in any type of field
– to conduct pest and disease monitoring in crop fields
– to ensure sustainable irrigation management, while taking the network features and limited available water supplies into account.

An analysis of sugarcane growers' activity models also highlighted differences between farms equipped with tillage machinery or transportation vehicles and farms with very little equipment (the most common situation). Equipped farms were able to maintain their fields, with suitable crop yields, and had time for agricultural diversification. Under-equipped farms were found to be dependent on external services (e.g. agricultural contractors, mutual aid) and were unable to comply with the cultivation timetable, with planting often done late and under poor conditions.

OSIRI-R+ FOR WATER RATIONING MANAGEMENT

In 2004, subsequent to finalization of OSIRI-RUN, a derivative software package (OSIRI-R+) was developed. OSIRI-RUN calculates irrigation flow rates that will keep crop water consumption (real evapotranspiration, ETR) at a peak level (maximum evapotranspiration, ETM). OSIRI-R+ can be used to control irrigation so as to achieve an ETR/ETM rate of less than 1 in terms of fulfilling crop water requirements, i.e. a minimal water supply—this rate is maintained unless there is rainfall. OSIRI-R+ has now been tested for irrigation management in water rationing experimental plots.

Improving water management in Réunion

Effect of water rationing during the first third of the cropping cycle

J.L. Chopart, L. Le Mezo, R. Nativel, B. Mouny, J.L. Brossier, M. Mezino, J.P. d'Export

A trial has been under way since 2000 in Saint-Pierre to study the effects of stopping or sharply reducing irrigation during the first third of the cropping cycle (40 to 120 days after ratooning). The 2003-2004 results confirmed the potential benefits of rational reduction of watering during the first third of the cycle (relative to recommended dosages). In 2003-2004, rainfall was high during the initial part of the cycle, i.e. 243 mm up to 51 days after ratooning. No water stress was noted in the early water rationing treatment (from 52 to 79 days). The treatment involving later rationing (from 80 to 130 days after ratooning) underwent water stress with a reduction in plant growth, but without a significant effect on sugarcane yields (trial mean: 133 t/ha, CV: 6.5%).

Analysis of variability in irrigation practices

R. Pirot, M. Gueno, R. Nativel

The shortcomings of the first data collection system on irrigation practices based on periodic water consumption readings were soon obvious, i.e. measuring water supplies on a 15-day basis was insufficient for analysing different farmers' practices. A decision was thus made to install equipment capable of accurately monitoring these practices. This installation is under way and involves a data acquisition unit fitted with a counter for continuous water-use monitoring.

Monitoring counters and an automatic irrigation valve in Réunion.
© R. Pirot

Demonstration plots were also to be set up on some farms. Irrigation on each of these farms will be controlled automatically. A first automatic irrigation management program was developed (Figure 2). It includes the same data acquisition system as that used to record farmers' water consumption data, and during the day it automatically switches on irrigation of the demonstration plot from a water tower supply. The system is connected to a rain gauge and is based on calculation of the water balance in each plot. It has been validated in a controlled environment.

Daily rainfall measurement	Rainfall measurement during irrigation	Measurement of irrigation water volume
ETM calculation based on astronomical radiation	- astronomical radiation (according to the location) - ETP_o (potential evapotranspiration at sea level) - elevation gradient - ETP (potential evapotranspiration at the considered elevation) - crop coefficient Kc (FAO standard or temperature sum)	
Daily water balance calculation	$AM_d = AM_{d-1} - ETM_d + Rain_{d-1} + (Irrigation_{d-1} \times \text{network efficiency})$ (AM, available soil moisture; ETM, maximum evapotranspiration)	
Calculation of irrigation needs	- daily needs = $AM_{maxi} - AM_d$ - irrigation = daily needs/network efficiency - estimated needs = daily needs + fraction of water needs of the following round	
Irrigation control	- if $AM_d < AM_{mini}$ ➔ valve opened - if estimated needs > available volume ➔ valve opened	
Irrigation stopped	- if rainfall during irrigation + supplied volume > irrigation ➔ valve closed - if supplied volume > available volume ➔ valve closed	

Figure 2. Calculation of automatic irrigation management in a control plot.

Quality control of the meteorological network managed by CIRAD in Réunion

R. Pirot, M. Mezino, R. Nativel, J.L. Brossier

Extension of the meteorological network

In Réunion, CIRAD has been managing a network of agrometeorological stations for more than 20 years. In 2001, at the request of the sugarcane sector and in partnership with Météo France, this network was extended to the current level of 45 automatic stations, including 30 synoptic stations and 15 rain gauges. Readings are taken daily at these stations and the data are assessed, validated and stored.

Three quality control initiatives

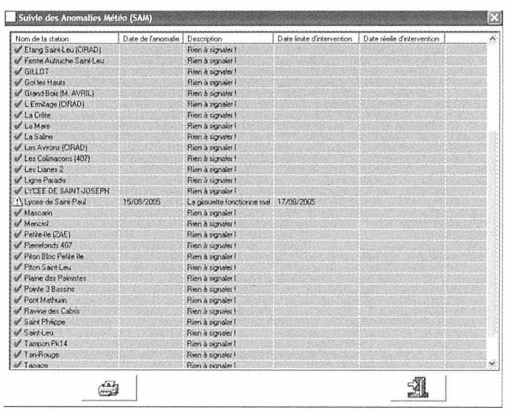
In Réunion, as part of the extension of the agrometeorological network, a quality control plan was drawn up. The functioning of the meteorological stations must be carefully monitored to ensure the quality of the measured meteorological data. The stations are thus visited regularly and all collected data are systematically controlled on a daily basis. A data error detection program was designed for this monitoring process. This software, which is integrated in GESMET version 2, includes three quality control modules:
– support for the detection and correction of meteorological data errors
– monitoring of operations required to correct meteorological data errors noted at the stations (meteorological data error monitoring, SAM)
– reporting of information concerning operations carried out at the stations.

Detection and correction of meteorological data errors

Data anomalies can occur as a result of an information transmission error. This generally leads to an absence of data for the station on the day it is queried. The software just advises the user to reiterate the query. A malfunctioning telephone line can cause these errors, but they are usually due to a sensor failure.

The data error monitoring module of the software indicates the station, type of error and proposes a correction value. This new value can then be submitted to the database and the error can be reported to the station maintenance technicians.

Figure 3. Screenshot of the meteorological data error monitoring module.



Meteorological data error monitoring module

The station maintenance technician uses the SAM data error monitoring module to check the status of the network. All of the meteorological stations are listed in this module. Reports on stations for which errors have been detected differ from those of the other stations (Figure 3). The technician thus obtains a summary of required interventions and potential replacement sensors to take on the station visit. After the intervention, the technician reports the intervention on the error display form (Figure 4). Finally, the database manager validates the intervention and erases the error once the problem has been solved.

Information reports

Details on all station interventions, detected errors and their solution are listed in a table that can be queried to determine why some data are not available for one station on a specific day (Figure 5).

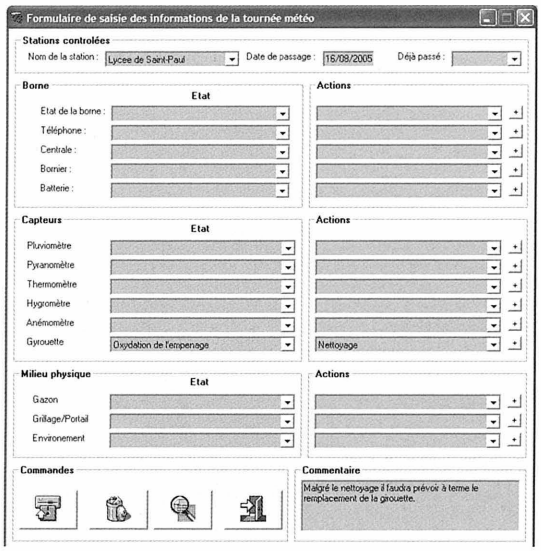


Figure 4. SAM data entry form for the meteorological station inspection visit.

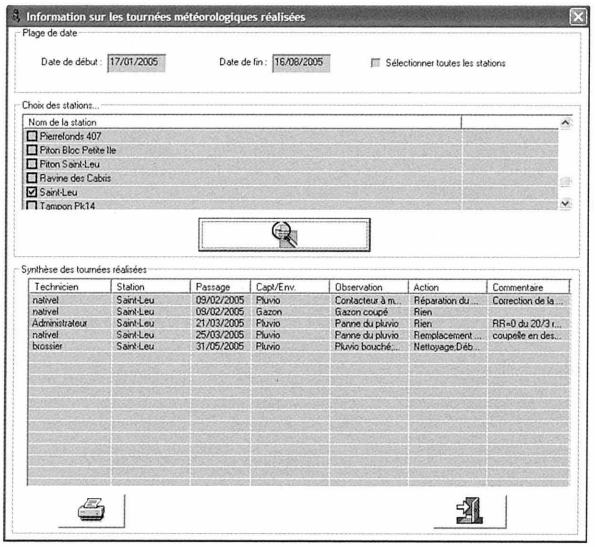


Figure 5. Screenshot of an information report concerning a meteorological station inspection visit.

Weed management: certification of two herbicides

P. Marnotte, J.J. Esther

In June 2004, the herbicides S-metolachlore and mesotrione were authorized for use with sugarcane.

Very little research has been undertaken to evaluate herbicides for their potential use in sugarcane fields. However, a broader range of herbicides authorized for use with sugarcane is now urgently needed in France because of official application restrictions.
In Réunion, the Service régional de la protection des végétaux (SPV) and CIRAD have thus been carrying out herbicide efficacy trials since 2002. These tests take the marked soil and climatic variations and the selectivity of herbicides relative to sugarcane varieties into account. The results are then confirmed through other official trials conducted by crop protection teams in Guadeloupe and Martinique. These official tests are required for the certification of new herbicides. In June 2004, this process resulted in the certification of two herbicides, i.e. S-metolachlore and mesotrione.

Modelling sugarcane growth

J.F. Martine, G. Vignais, M. Jeannette, E. Hoarau

Enhancement of the SIMULEX platform and the MOSICAS model

The SIMULEX simulation platform was completely updated in 2004 and integrated with the MOSICAS model. SIMULEX will likely not be further modified except with respect to simulation displays. The following features of the MOSICAS model will, however, be modified in 2005:
– plant cane and varieties cropped in Réunion and Guadeloupe taken into account
– long cropping cycles taken into account
– detailed LAI (leaf area index) taken into account to facilitate integration of new varieties
– improved simulation of sugar content and plant growth (stalk elongation).

MOSICAS is being used as a scientific collaboration, diagnosis and decision support tool in Réunion, Guadeloupe, Brazil and Morocco.

Initial results on sugarcane ripening

Sugarcane growth (stalk elongation) and ripening (Brix %) were monitored in ongoing trials with the aim of improving the simulation of sugarcane growth and sugar content. Growth was monitored in at least 30 cane plants per treatment by measuring the stalk elongation. Ripening was monitored in 5-10 cane plants per treatment, by measuring the Brix with a digital refractometer at five equidistant points on the stalk ("5-point Brix").

Validity of the ripening assessment method

We first highlighted a direct linear relation ($r^2 = 0.98$) between the 5-point Brix measurement in the field and the sugar content in the laboratory—the field 5-point Brix is a relevant indicator of the degree of ripeness. This relation overcame the need to conduct replicate sugar content measurements in the CERF laboratory, which can only be performed (but this measurement is very complicated) during the harvesting season.

Hence, during the sugarcane harvesting season and with the same sugarcane batches, which were likely at different degrees of ripeness (juice Brix: 8-25%), we compared the field 5-point Brix with conventional press measurements performed in the CERF laboratory. The field 5-point Brix measurements were very close to the Brix ($r^2 = 0.98$) and sugar content ($r^2 = 0.98$) measurements determined in the laboratory using ground samples. This was also the case for the sugarcane moisture estimates. Correlation analyses are under way to assess the purity and fibre levels on the basis of 5-point Brix measurements.

Ripening patterns of cv R570

Based on analyses of correlations determined with MOSICAS, the 5-point Brix measurements obtained for cv R570 generated interesting results. The Brix was

found to depend more on the period of the year or the calendar day (r^2 = 0.88) than on the age of the sugarcane crop (r^2 = 0.69). The ripeness according to age was highly dependent on the type of cycle (plant cane, ratoon), elevation (highlands or lowlands) and harvesting or previous planting date (Figure 6).

The ripeness curves in Figure 6 differ substantially according to the factors studied. Sugar accumulation thus begins very early, i.e. around 80-100 days for a ratoon crop cut at the end of the previous season, and around 200-250 days for highland sugarcane planted in March. The Brix peaked at a higher level (24%) for lowland sugarcane as compared to highland sugarcane (21%). In ratoons, ripeness was reached in the lowlands for sugarcane under 12 months old and in the highlands for sugarcane over this age. In plant cane, ripeness was reached in the lowlands at 14 months, and later in the highlands. Finally, ripeness was reached earlier (beginning of Brix) and more intensely (curve slope) in the lowlands as compared to the highlands, in ratoons as compared to plant cane, and in sugarcane at the end of the harvesting period as compared at the beginning of the cropping period. These results should be reconfirmed for cv R570 and other varieties in 2005.

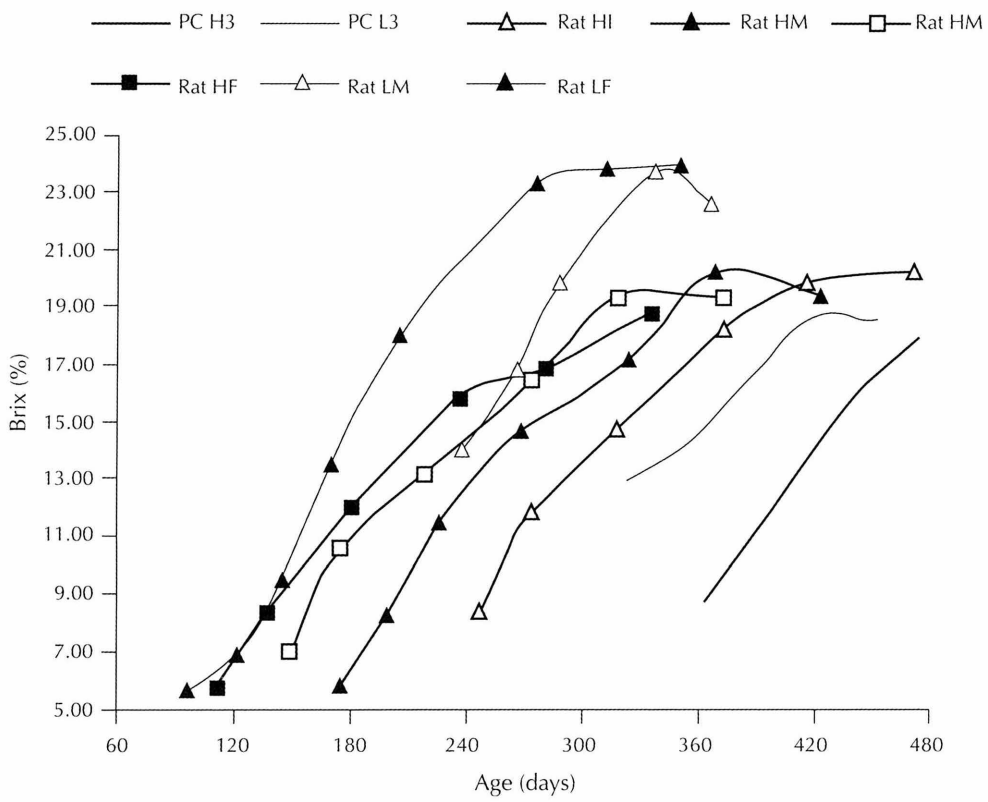


Figure 6. Variations in Brix (% juice) in the field according to the sugarcane age, cycle, elevation, planting or previous harvesting date.
PC: plant cane; Rat: ratoon; H: highlands, 800 m; L: lowlands, 50 m; 3: March planting; I: previous initial harvests; M: previous middle harvests; F: previous end of cycle harvests.

Cropping cycle calibration

It would be virtually impossible to set up tests to assess cropping cycle calibration in such complex situations (elevation, cycle type, crop age, harvest or previous planting date, year effect). However, the MOSICAS model, which has been prevalidated for Brix monitoring under various conditions, can simulate cropping cycle calibrations.

In ratoons with cv R570, studies of correlations between the Brix and climatic indicators (temperature, solar radiation, crop-water requirement fulfillment rate) simulated by MOSICAS revealed that the period of the year is important ($r^2 = 0.88$) and that climatic effects are more important during the millable stalk formation phase ($r^2 = 0.82$-0.87) than the time from planting or the previous harvest ($r^2 = 0.2$-0.85).

A first simple and efficient statistical model was developed:
juice Brix (%) = $-1.53 + dcal/10 - (1.71 \times 10^{-4} \times dcal^2) + (2 \times 10^{-3} \times dd)$
with
$r^2 = 0.954$; standard error = 1.03, d.f. = 53
dcal: calendar day of the year
dd: sum of degree-days from harvest or planting (threshold = 12°C).

Geographical and varietal validity of the MOSICAS model

J.F. Martine, M. Aabad (CTCS), C. Suguitani (ESALQ, Brazil), P. Todoroff, S. Catsidonis

Thesis research in Morocco and Brazil has been focused on the geographical and varietal adaptation of the MOSICAS model. Specific experiments were set up in 2003 and 2004. The model is to be adapted in 2005 and 2006. Observation data collected in Guadeloupe on cv R570 and other local commercial varieties will also be used to validate the model.

Harvest forecasts in Réunion

The MOSICAS growth model can provide production indicators to explain yield variations. The sugar industry in Réunion (factories and CTICS) requested CIRAD's support to determine the reasons for the differences between production levels estimated for the purpose of harvest planning and the levels actually obtained.

A study of correlations between observed production levels and bioclimatic indicators simulated by a biophysical model (MOSICAS) over a given period (1995-2000) gave rise to statistical models capable of forecasting these production levels. These statistical models could then be used for sugarcane production forecasting the following years (2001-2004). The method was described in the previous *Sugarcane Annual Report 2003* and was not modified for the 2004 estimations. The correlations used for 2003 were reevaluated for 2004 on the basis of 2000 to 2004 production levels and assuming that the areas were stablized. The results are presented with comments in Table 1.

Table 1. Estimated sugarcane production and errors relative to actual production in Réunion (2004), according to three methods: model (CIRAD), surveys (factories), sampling (CTICS).

Sites	Error (%)			Estimated yield (1 000 t)			Actual yield (1 000 t)
	Model	Survey	Sampling	Model	Survey	Sampling	
Cropping areas							
Beaufonds	– 8.87	– 6.25	–	452	465	–	496
Bois-Rouge	1.86	– 4.42	–	438	411	–	430
Savanna	12.15	1.4	–	240	217	–	214
Le Gol	3.56	0.84	–	494	481	–	477
Grands-Bois	0.85	– 1.7	–	356	347	–	353
Sugar factories							
Bois Rouge	– 4.08	– 5.31	– 7.65	940	928	905	980
Le Gol	5.16	0.4	0.2	1 040	993	991	989
Total production in Réunion							
	0.56	**– 2.44**	**– 3.71**	**1 980**	**1 921**	**1 896**	**1 969**

Table comments:
– Beaufonds Bois-Rouge cropping areas. Very low estimation for Beaufonds, which could be explained by transfers between cropping areas, or by a decrease in sugarcane cropping area at Beaufonds
– Savanna cropping area. The estimate provided is a mean production level for the last 2 years since a modelling simulation was not possible because of variations in the areas and in crop management sequences
– Gol cropping area. The overestimation was likely due to severe drought at the middle and end of the season and to the fact that irrigation in this area was not taken into account
– Grand-Bois cropping area. Production in this area was correctly estimated, as during previous years
– Sugar factories. Production for the Gol sugar factory was again overestimated (> 5%) because of the increase in area in the Savanna cropping area and the drought at Le Gol during the cropping season
– Total production in Réunion. The estimation was excellent (+ 0.6%), even better than in 2003 (+ 2%). Integration of the production history thus enhances the prediction potential of the model and the correlations.

Mapping the agricultural area in Guadeloupe

P. Todoroff, N. Lubin, S. Catsidonis

AGRIGUA project successfully completed

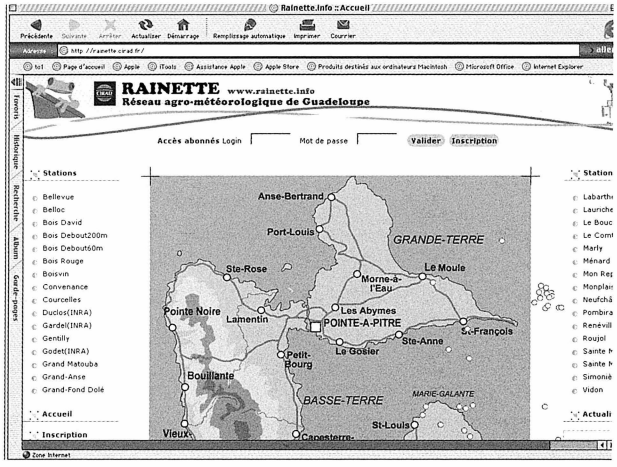
The Direction de l'agriculture et de la forêt (DAF, agriculture and forest authorities) asked CIRAD to coordinate the first year (2002) of the AGRIGUA (Association guadeloupéenne de recueil d'informations géographiques d'utilité agricole) project. The aim of this project was to set up a geographical information system (GIS) to assess agricultural patterns and thus enable users to meet requirements with respect to current agricultural subsidization procedures and future European directives (2005).

CIRAD set up a team and an operating structure to enable regular updating of the agricultural situation (GPS surveys, satellite images, etc.): installation of equipment (premises, GPS, computers, software, etc.), recruitment and training of GPS technicians, development of survey and field measurement methods, organization of information exchanges between partners and GIS maintenance. Almost all crop fields have now been referenced in the GIS database of the AGRIGUA project.

In 2004, the AGRIGUA association was formed and took over coordination of the project. CIRAD is the association secretary and, like all members, has permanent access to the database.

RAINETTE
A NEW INFORMATION SYSTEM IN GUADELOUPE
P. Todoroff, J.B. Laurent

The RAINETTE (Réseau agro-météorologique de Guadeloupe) meteorological database is now available online at http://www.rainette.info



SUCRETTE project—remote sensing sugarcane monitoring

The SUCRETTE (Suivi de la canne à sucre par télédétection) project was launched with funding from the Terre et Espace network with the aim of developing spatial applications that could be used in agriculture and of setting up a GIS for monitoring yield and sugarcane harvesting via periodic very high spatial resolution satellite images.

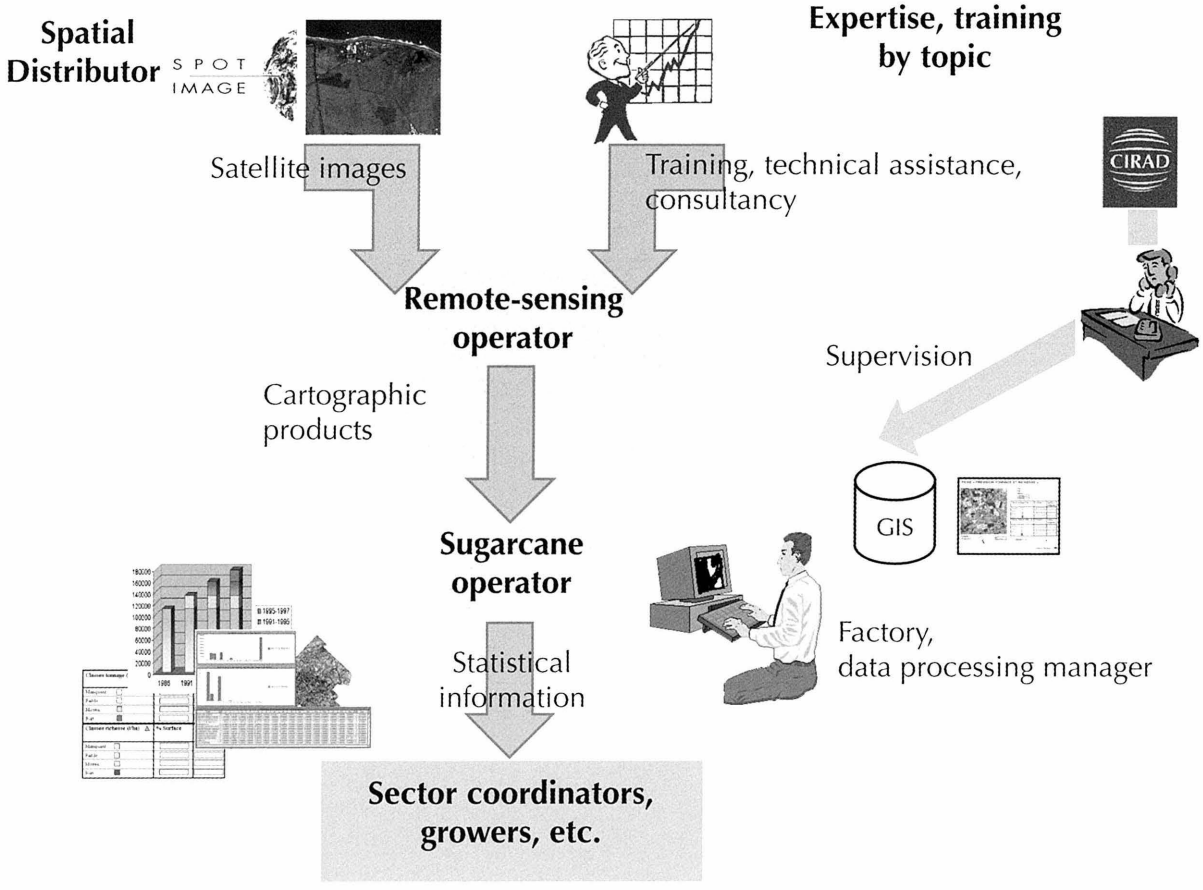
The SUCRETTE project will assess three experimental sites in Réunion, Mauritius and Guadeloupe. The project already has access to a database on the Gardel experimental site in Guadeloupe. Sugarcane growth modelling studies have led to the development of a sugarcane harvest forecasting tool for Guadeloupe. The satellite images obtained will also be used for the AGRIGUA project, and they will be purchased and analyzed (plot delineation and landuse determination) jointly via the two projects.

A management support system was developed for the sugarcane industry. This system includes a GIS, designed to assess agricultural patterns, combined with a production model and supplied with time-series Earth images.

The project results highlighted that this sugarcane cropping area monitoring tool is technically feasible for local communities (harvest monitoring maps, crop

growth monitoring, yield forecasting support), while also providing an agricultural support tool for large- and medium-scale plantations (intra- and inter-plot heterogeneity maps, growth defects, crop damage, etc.).The information derived from these tools (Figure 7) could be generated by a remote-sensing operator and distributed to users by a sugar industry operator, i.e. companies specialized in remote sensing and the sugarcane sector).

Figure 7. Potential information distribution organization and networks.



Support to the sugarcane sector and producers

The Support to the sugarcane sector and producers research group provides assistance to sugarcane growers and sugar producers on the basis of results obtained from the other research projects undertaken within the Programme. This research group:
– offers support to sugar producers in the French overseas departments (DOM), in Africa and Asia
– validates and implements decision-making tools.

The Support to the sugarcane sector and producers research group is coordinated by Pierre Langellier-Bellevue.

CIRAD, Sugarcane Programme, 2004

Mechanization of the sugarcane cropping area

Increased production costs, mainly due to an increase in inputs and a shortage of farm labour, generally boosts expenses for manually harvested sugarcane. Moreover, the decision of the Common Organisation of the Market to lower sugar prices forced the profession to seek new ways to enhance productivity, even though the losses are partially offset by EU and French subsidies.

Mechanized harvesting in Réunion

D. Deurveilher

In Réunion, manual harvesting costs have now reached €17/t of harvested sugarcane. Mechanization is one means of increasing productivity, but heavy investment is required to replace manpower by machines and the improvement of local land conditions is also a prerequisite. General discussions on preliminary field preparation, on both farm and sugarcane-growing area scales, should be immediately initiated with respect to the type of machines to be used. All ways to lower production costs should be carefully analysed because there is very little leeway.

Conditions for forming farm groups for mechanized harvesting

Prior to forming a group for mechanized sugarcane harvesting, it is essential to study the location of each farm in relation to the delivery site: distance from the farm to the weigh bridges, potential mechanized area, and areas immediately ready for mechanized harvesting. In 2004, a first study was carried out for the Groupement de récolte de la zone ouest.

Field location. The plots to be harvested were selected from a DAF referenced sugarcane plot database. This database contains information on agricultural plots on farms in Réunion and is updated on the basis of farmers' annual declarations. Several parameters were assessed, including:
– the location of all concerned growers in the area
– all cropping areas in the zone, managed plots, unmanaged plots and possibilities of expanding the plots
– the distance between plots and weigh bridges
– the most suitable transportation route
– the number of trailers required on the plot when harvesting chopped cane (according to the distance)
– organization of the cropping calendar and the harvesting circuit in the area.

Harvester cost-effectiveness. Investment in a harvester can vary according to the type of machine, specific subsidies and the financing conditions. This purchase leads to fixed expenditures that can be calculated and variable expenditures that depend on the operating conditions. Guidelines are needed because of the absence of local references on the machinery operating costs under harsh conditions. Guidelines are available for the SIMON whole sugarcane harvester. For chopped cane harvesters, the data are not representative of the special conditions prevailing in western and southern Réunion. The aim is to obtain a price per harvested tonne that is equal to or lower than the per-tonne cost for manually harvested sugarcane.

Sugarcane cropland planning for mechanized harvesting

Three key parameters must be considered when developing a field, farm or a cropping area to enhance machinery performance, i.e. the topography, windrow positions and access roads.

The mechanization potential of a plot and subsequent development plans depend on the topography. The rows should be as long as possible. The windrow positions are determined according to the geometry of the plot, while also taking the cost-effectiveness and erosion control considerations on steeply sloped land into account. In irrigated areas, e.g. western Réunion, sugarcane can be planted during drought periods (September to October) even if the land is sloped, because this crop provides sufficient cover to protect the soil during heavy year-end rainfall periods. Crossfall slopes should be avoided when harvesting chopped cane because loaded trailers would not be able to follow the harvester. This is a key point when levelling raised areas during operations to develop the plot for machinery use.

Finally, plot access roads should have two functions, i.e. provide access and a turnaround area for the harvester at the edge of the field, thus reducing the width of the field.

Mechanization of the sugarcane-cropping area in Guadeloupe

J.C. Dagallier, T. Pierre (ENITA trainee, CTICS, INRA, CIRAD), G. Masson (SICA Canne trainee, CIRAD)

Turnaround area at the edge of the field—permanent stump damage.
© J.C. Dagallier

An assessment of the mechanization situation in Guadeloupe was initiated in 2004. Machinery, service providers, the mechanized cultivation chain and work quality were evaluated. The conclusions indicated that mechanization should be substantially improved and technical training sessions set up concerning specifications, calibration, and good machinery usage and maintenance.

Machinery assessment. There are many machines. Few farms are equipped, and mechanized operations are carried out by service providers using machinery that is high-powered (tractors > 110 CV), not very diversified, heavy (trailers with a 25 t carrying capacity for transporting sugarcane from the field to relay centres, tractors of over 6 t). The machines are

designed for road transport (carrying capacity, wheel-base width) but not for manoeuvring in fields. These machines are very expensive to purchase, and even more so for the island of Marie-Galante due to the added shipping cost. The machinery brands and markets are shared amongst three main distributors.

Service provider assessment. These providers are mainly involved in mechanized harvesting and transportation. There are many official CUMA cooperatives and ETA agricultural contractors. Very few individual sugarcane growers are involved (2% of deliveries, i.e. less than 20 000 t of sugarcane, for an annual total harvest of 880 000 t). Cane transportation is easy and profitable and thus mainly carried out by contractors, but to the detriment of tillage, manuring and weeding operations. Finally, during planting, preliminary cultivation operations are mechanized, but the cuttings are still planted manually.

Mechanized cultivation chain and work quality assessment. Soil compaction problems arise because guidelines are not followed. The most common mechanized cultivation chain includes: shallow ploughing, 1st tillage (ploughshare), 2nd tillage (ploughshare), secondary tillage (disc share), furrowing + manure application, amendments, filter mud or stillage + preemergence herbicides. It is hard to carry out all the different required operations at the right time due to the lack of available machinery (e.g. tractors, which are deployed for transportation purposes) during a period of unsettled weather conditions (December to May). These operations are thus often conducted at unsuitable times, without compliance with specifications or taking the characteristics of the field into consideration. Production costs are therefore very high (Table 1): too many operations, per-hectare operation time generally too long.

Mechanized harvest.
© T. Fovet.

Table 1. Cultivation operation costs for sugarcane planting in Guadeloupe in 2004 (Sources: CTICS, SICA Canne).

Operation	Mean price (€/ha)
Shallow ploughing	119
1st tillage	154
2nd tillage	123
Secondary tillage	85
Furrowing	77
Subtotal	***558***
Manure	299
Amendments	228
Subtotal	***527***
Preemergence herbicides	74
Postemergence herbicides + borders	338
Cuttings (10 t/ha)	503
Subtotal	***915***
Total planting cost (apart from preliminary cultivation)	967
Total plantation	***2 967***
Harvesting	
Mechanized harvest cost (cutting)	€15/t
Manual harvest cost (cutting)	€22/t

Projects geared towards improving the organization of service provider interventions have been requested by CTSR (Comité technique de suivi des récoltes) the SICAs. The plan is to reassess the cost of some operations (stillage, filter mud and ash spreading) and also to set up a monitoring and training system for harvesting (CTSR) and cultivation operations (SICA). The focus should be especially on harvesting conditions (use of heavy machinery under very wet conditions), which could have a negative impact on the agricultural results of the industry—recommendations should be given to work contractors.

Enhancement of production quality and organization of mill supplies

C. Lejars, S. Auzoux, S. Laurent

An employment-generating sector

In Réunion and South Africa, sugarcane is a major agricultural economic sector.
In Réunion, the sugar industry accounts for 27% of agricultural production and 6 000 related jobs. In South Africa, 50% of the sugar produced is exported and this sector provides income for 40 000 smallholders, alongside 1 700 large-scale sugarcane farms which supply around 80% of the volume of sugarcane to be processed.
Several problems are now affecting these subsectors so the industry is looking for ways to increase efficiency and alternative end products (fuel/ethanol; materials).

CIRAD is addressing two main objectives in Réunion and South Africa, studying:
– sugarcane supplies to sugar factories: delivery planning and quality enhancement
– factors that induce quality variations at different levels (plot, farm, sugarcane-growing area).

This research was carried out with the support of the Decision Support and Biostatistics team of CIRAD's Annual Crops department.

Mill supply organization

Simulation tools were used to develop new methods of organizing sugarcane supplies to sugar factories—these methods take sugarcane quality into account and enhance the cost-effectiveness of the sector. Profits resulting from the implementation of these new sugarcane supply systems have to be equitably redistributed. In 2004, in Réunion and the Sezela sugarcane-growing area in South Africa (in collaboration with SASRI), an in-depth analysis was conducted on the impacts of these organizational changes on the management of sugarcane flows and on payment scheme patterns. Concerning this latter point,

Loading sugarcane.
© S. Laurent

the assessments focused on two topics: sugarcane payment systems and the influence of remuneration on the actual regularity of sugarcane supplies to factories and on the quality of the delivered cane.

MAGI sugarcane supply simulation model

The MAGI model, which was initially designed for Réunion, can be used to assess the impact of sugarcane supply organization scenarios. In 2004, a generic model was programmed in Visual Basic® for applications in South Africa and other sugar-producing countries.

Payment system assessment

The impact of different payment systems was investigated as part of the study on modifications in sugarcane supply organization aimed at promoting quality. A calculation tool was developed in Excel to calculate the total value generated by a new supply organization method, and to evaluate the effects of payment systems on growers' income and on the redistribution of this value between growers and suppliers.

Simulations were performed for the Sezela sugar factory in South Africa. A study is under way in Réunion, but it will take longer because the number of growers to consider is 20-fold greater than the number in South Africa.

In 2004, this tool was used to assess the impact of reorganizations on planters' income according to three payment formulas and three organization methods. The between-grower distribution of value generated by the industry was also assessed.

Product quality

In Réunion, a statistical study was carried out in collaboration with the GoI sugar factory (Saint Louis) to identify climatic and physiological factors that could explain the technical deviation (in %) noted in the factory. This technical deviation is the difference between the sugar content of sugarcane entering the factory and the actual amount of sugar produced in the factory with this sugarcane. The aim was to determine the relationship between these parameters, the mean technical deviation for the season and the weekly deviation patterns during the season.

None of the tested factors considered separately was closely correlated with the mean technical deviation. Multivariate analyses were performed to come up with explanatory models. On an annual level, the low number of observations relative to the number of potentially involved variables hampered the search for a model to predict the mean technical deviation. The model should thus be validated in the near future. Concerning the weekly technical deviation, climatic and physiological variables could be integrated to obtain a statistically satisfactory explanation for the mean technical deviation. The study showed that the analyses should be differentiated according to years by incorporating a climatic year effect in the models. The models will be validated with supplementary data in 2005-2006.

Development of decision-support tools

J.L. Chopart, L. Le Mezo, M. Mezino

OSIRI-RUN irrigation consulting tool

In 2003 and 2004, OSIRI-RUN (a simple tool for individual irrigation management in Réunion) was developed by CIRAD at the request of the Chambre d'agriculture of Réunion. In addition to the feasibility and acceptability tests under way on farms, a experiment was set up to test three tools—OSIRI-RUN, IRRICANE and ETM (maximum evapotranspiration, i.e. crop water needs). Instrumentation has been installed for this experiment (water balance sensors, lysimeters, rhizotrons). The relevance of consulting recommendations drawn up with the help of OSIRI-RUN could thus be assessed, especially by comparing measured drainage flows with those simulated with OSIRI-RUN.

Simulation of irrigation water consumption with M-CIDER

The SIMULIRRIG software package has been used until now to determine irrigation water needs (volume, peak flow rates) for sugarcane-growing areas. It can be connected to a meteorological database to generate decision-support data for designing irrigation networks.

In 2004, a complementary tool, i.e. M-CIDER (modelling irrigation water consumption according to the irrigation system, environment and water supply) was finalized. M-CIDER estimates theoretical irrigation water needs on a plot and farm scale while taking, like SIMULIRRIG, the different constraints (climate, soil, irrigation plan, irrigation efficiency) into consideration. M-CIDER also takes other constraints into account that may affect farmers using conventional practices: maximum flow rate at the terminal, water outages and controlled flow. This tool is used within the framework of the PCSI (Projet commun des systèmes irrigués) project in Réunion to compare irrigation water consumption levels recorded on farms and theoretical irrigation water needs simulated with this tool.

Support to the Senegalese sugar company

D. Marion P. Marnotte, M. Sene, A. Obiang

Tests underway since 2003 at the Compagnie sucrière sénégalaise (CSS) in Richard-Toll have generated results in the following fields: sugarcane breeding, weed control, irrigation, tillage, and crop management sequences. Some of these results, such as dryoff irrigation for sugarcane crops and *Cyperus esculentus* control, are especially interesting.

Dryoff irrigation for sugarcane crops

For fields under flood irrigation, it is crucial to stop irrigation (dryoff) several weeks prior to harvesting in order to facilitate the movement of cane loading and

transportation vehicles. CSS feared that this could lead to a drop in sugarcane technological quality, and thus decided to apply a short dryoff period (15-21 days). This did not, however, enable sufficient drying of the soil and led to mudding up of tractors during harvesting, and subsequent destruction of sugarcane stumps—yields thus declined the following season.

In 2003-2004, 10 trials were set up to study the effects of dryoff irrigation times on the technological quality of sugarcane. The dryoff period was adjusted according to the evapotranspiration level just prior to harvesting the plot. For all tested varieties (N14, B63118, SP701284 and Co6806), sugarcane technological quality was optimal during the peak harvesting period, and dryoff irrigation had no impact on this quality relative to sugarcane of the same age that was still being watered. No decrease in technological quality was noted when the dryoff period was extended to 30 days for sugarcane harvested at the beginning of the season (E_{pan} = 6.5 mm), to 25 days at mid-season (E_{pan} = 7.7 mm), and to 22 days at the end of the season (E_{pan} = 12.3 mm). A dryoff irrigation period of as long as 40 days at the beginning of the season had little effect. However, on light soils, the dryoff irrigation period should not be extended beyond the recommended times (25 and 22 days, respectively) as of the middle of the season, and especially at the end.

Controlling *Cyperus esculentus*

Cyperus esculentus is highly invasive in fields harvested at the middle and end of the season and cannot be effectively controlled with standard herbicides, i.e. ametryn (+) 2,4-D + ioxynil. Moreover, these compounds are phytotoxic to susceptible varieties such as B63118 and Co6806. Post-emergence efficacy trials showed that *C. esculentus* can be suitably controlled via two applications, at a 1-month interval, of 1 440 g/ha of bentazone + 1 200 g/ha of 2,4-D or 1 200 g/ha of MCPA.

Herbicide trial.
© P. Marnotte

Appendices

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Publications

▸ High impact peer reviewed periodicals

Asnaghi C., Roques D., Ruffel S., Kaye C., Hoarau J., Telismart H., Girard J., Raboin L., Risterucci A., Grivet L., D'Hont A. 2004. Targeted mapping of a sugarcane rust resistance gene *(Bru1)* using bulked segregant analysis and AFLP markers. Theoretical and Applied Genetics, 108 (4): 759-764.

Domaingue R. 2004. Research on sugarcane at CIRAD. International Sugar Journal, 106 (1272): 673-675.

Jannoo N., Grivet L., David J., D'Hont A., Glaszmann J.C. 2004. Differential chromosome pairing affinities at meiosis in polyploid sugarcane revealed by molecular markers. Heredity, 93 (5): 460-467.

Rassaby A., Girard J., Lemaire O., Costet L., Irey M.S., Kodja H., Lockhart B.E.L., Rott P. 2004. Spread of *Sugarcane yellow leaf virus* in sugarcane plants and fields on the island of Réunion. Plant Pathology, 53 (1): 117-125.

Roumagnac P., Gagnevin L., Gardan L., Sutra L., Manceau C., Dickstein E.R., Jones J.B., Rott P., Pruvost O. 2004. Polyphasic characterization of wenthomonads isolated from onion, garlic and Welsh onion (*Allium* spp.) and their relatedness to different *Xanthomonas* species. International Journal of Systematic and Evolutionary Microbiology, 54: 15-24.

Royer M., Costet L., Vivien E., Bes M., Cousin A., Damais A., Pieretti I., Savin A., Megessier S., Viard M., Frutos R., Gabriel D.W., Rott P. 2004. Albicin pathotoxin produced by *Xanthomonas albilineans* is encoded by three large PKS and NRPS genes present in a gene cluster also containing several putative modifying, regulatory, and resistance genes. Molecular Plant-Microbe Interactions, 17 (4): 414-427.

Ruiz M., Rouard M., Raboin L., Lartaud M., Lagoda P., Courtois B. 2004. TropGENE-DB, a multi-tropical crop formation system. Nucleic Acids Research, 32: D364-D367.

▸ Low impact peer reviewed periodicals

Grivet L., Daniels C., Glaszmann J.C., D'Hont A. 2004. A review of recent molecular genetics evidence for sugarcane evolution and domestication. [On line]. Ethnobotany Research and Applications, 2 (1): 9-17. <URL: http://www.ethnobotanyjournal.org/vol2/i1547-3465-02-009.pdf>.

Le Gal P.Y., Lejars C., Lyne P., Meyer E. 2004. De la diversité spatiale aux performances des bassins d'approvisionnement : cas des sucreries de canne. Cahiers Agricultures, 13 (6) : 554-562.

Lejars C., Siegmund B. 2004. Overview of Réunion sugar industry. Proceedings of the South African Sugar Technologists' Association, 78: 29-37. Annual Congress of the South African Sugar Technologists' Association. 78, 2004/07/27-30, Mount Edgecombe, South Africa.

Way M.J., Goebel R., Conlong D.E. 2004. Trapping *Chilo sacchariphagus* (Lepidoptera: Crambidae) in sugarcane using synthetic pheromones. Proceedings of the South African Sugar Technologists' Association, 78: 291-295. Annual Congress of the South African Sugar Technologists' Association. 78, 2004/07/27-30, Mont Edgecombe, South Africa.

▸ Non-peer reviewed periodicals

D'Hont A. 2004. Canne à sucre et cannes sauvages : origine et structure des génomes. Comptes Rendus de l'Académie d'agriculture de France, 90 (3): 23 (1 p.). Séance La canne à sucre : origine, génétique et amélioration variétale, 24 mars 2004, Paris, France.

Domaingue R. 2004. Pratiques de sélection chez une plante complexe à multiplication végétative. Comptes Rendus de l'Académie d'agriculture de France, 90 (3): 24-25. Séance La canne à sucre : origine, génétique et amélioration variétale, 24 mars 2004, Paris, France.

Jeuffrault E., Rolet A., Reynaud B., Manikom R., Georger S., Taye T., Chiroleu F., Fouillaud M., Vercambre B. 2004. Vingt ans de lutte contre le ver blanc de la canne à sucre à la Réunion : un succès, mais il reste des questionnements scientifiques pour confirmer la durabilité de la lutte biologique. Phytoma, la défense des végétaux, (573) : 16-19.

▸ Books

Rao G.P., (ed.), Salem Saumtally A., (ed.), Rott P., (ed.). 2004. Sugarcane pathology. Volume 3: Bacterial and nematode diseases. Enfield, New Hampshire, USA, Science Publishers, 358 p.

▸ Book chapters

Giglioti E.A., Almeida I.M.G., Clerc F., Rott P., Chatenet M., Beriam L.O., Carvalho M.L.V., Masuda Y., Matsuoka S. 2004. False red stripe in Brazil: Epidemiology and causal agent. *In* Rao G.P., (ed.), Salem Saumtally A., (ed.), Rott P., (ed.). Sugarcane pathology. Volume 3: Bacterial and nematode diseases. Enfield, New Hampshire, USA, Science Publishers, 127-134.

Goebel R. 2004. Biological control of *Chilo sacchariphagus* on the Indian Ocean islands and Africa. In Capinera J.L., (ed.). Encyclopedia of Entomology. Volume 2: F-O. Dordrecht, The Netherlands, Kluwer Academic Publishers, pp. 989-990.

Peterschmitt M., Rott P. 2004. Sugarcane streak virus diseases. *Sugarcane streak mastrevirus, Sugarcane streak Egypt mastrevirus, Sugarcane streak Mauritius mastrevirus. In* Lapierre H., (ed.), Signoret P.A., (ed.). Viruses and Virus Diseases of Poaceae (Graminae). Paris, France, Inra, pp. 711-714, (Mieux Comprendre).

Rao G.P., Girard J.C., Rott P. 2004. Current scenario and future perspectives of sugarcane bacterial diseases. *In* Rao G.P., (ed.), Salem Saumtally A., (ed.), Rott P., (ed.). *Sugarcane pathology. Volume 3: Bacterial and nematode diseases.* Enfield, New Hampshire, USA, Science Publishers, 3-12.

Rott P. 2004. Sugarcane red leaf mottle. *Peanut clump pecluvirus. In* Lapierre H., (ed.), Signoret P.A., (ed.). Viruses and Virus Diseases of Poaceae (Graminae). Paris, France, Inra, 709-710. (Mieux Comprendre).

Rott P., Davis M.J. 2004. Identification of sugarcane bacterial pathogens and assessing their genetic diversity using molecular techniques. *In* Rao G.P., (ed.), Salem Saumtally A., (ed.), Rott P., (ed.). Sugarcane pathology. Volume 3: Bacterial and nematode diseases. Enfield, New Hampshire, USA, Science Publishers, 175-183.

▸ Patent

Royer M., Gabriel D.W., Frutos R., Rott P. 2004. Complete biosynthetic gene set for synthesis of polyketide antibiotics, including the albicidin family, resistance genes, and uses thereof [Patent number WO 2004/035760 A2]. World: US Patent and Trademark Office, US Department of Commerce, n. PCT International Patent Application No. PCT/US2003/033142; WO2003US33142 20031017, 193. [2004/04/29].
< URL:
http://v3.espacenet.com/textdoc?DB=EPODOC&IDX=WO2004035760&F=0 >.

▸ Papers presented at colloquiums, seminars and conferences

Bégué A., Degenne P., Pellegrino A., Todoroff P., Baillarin F. 2004. Application of remote sensing technology to monitor sugar cane cutting and planting in Guadeloupe (French West Indies). 11 p. International Congress Geomatica 2004, 2004/05/10-14, La Havane, Cuba.

Brouwers M. 2004. La canne irriguée : une culture C4 C-séquestrante et protectrice de l'environnement. [Résumé]. In Roose E., De Noni G., Prat C., Ganry F., Bourgeon G. Gestion de la biomasse, érosion et séquestration du carbone. 2, Séquestration du carbone et érosion des sols = Land use, erosion and carbon sequestration. 2. Soil erosion and carbon sequestration. Paris, France : IRD, 515-516. (Bulletin du Réseau Erosion, n° 23). Colloque International sur l'Influence de la Gestion de la Biomasse sur l'Erosion et la Séquestration du Carbone, 23-28 septembre 2002, Montpellier, France.

Champoiseau P., Daugrois J.H., Girard J.C., Royer M., Rott P. 2004. Diversité génétique et variabilité intraspécifique du pouvoir pathogène de *Xanthomonas albilineans,* agent causal de l'échaudure des feuilles de la canne à sucre. *In* Résumés. UMR GDPP, IBVM, INRA, Université Victor Segalen Bordeaux 2, 87 (1 p.). Rencontres Plantes-Bactéries. 6, 11-15 novembre 2004, Aussois, France.

Chopart J.L., Mezino M., Le Mezo L. 2004. Relationship between altitude and monthly air temperature in western Reunion. [Abstract]. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (1 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM. 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Dagallier J.C. 2004. Problems with mechanical harvesting in small farms: discussions on the Simon harvester. [Abstract]. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (1 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Dijoux L., Jeuffrault E., Marnotte P. 2004. Course contre la montre pour l'homologation de spécialités herbicides de la canne à sucre dans les DOM. Enjeu de santé publique et de protection de l'environnement. *In* Journées internationales sur la lutte contre les mauvaises herbes. [Cd-Rom]. Paris, France: AFPP, [7 p.]. Conférence Internationale du Columa 19, 08-10 décembre 2004, Dijon, France.

Domaingue R. 2004. La recherche canne à sucre à la Réunion : un atout européen pour le développement local et le rayonnement régional et international. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (7 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Fouillaud M., Georger S., Morel G., Vercambre B. 2004. Current equilibrium level between *Hoplochelus marginalis* (Col. Melolonthinæ) a pest of sugar cane and its antagonist pathogen: *Beauveria brongniartii* (Deuteromycotina, Hyphomycetes). [Abstract]. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (1 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Fouillaud M., Georger S., Morel G., Vercambre B. 2004. Equilibre actuel entre *Hoplochelus marginalis* (Col., Melolonthinæ), ravageur de la canne à sucre et son pathogène antagoniste : *Beauveria brongniartii* (Deuteromycotina, Hyphomycètes). *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (10 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Ipou Ipou J., Marnotte P., Aman Kadio G., Ake S., Toure Y. 2004. Influence de quelques facteurs environnementaux sur la germination des semences d'*Euphorbia heterophylla* L.(Euphorbiaceae). *In* 12e Colloque international sur la biologie des mauvaises herbes. Paris, France: AFPP, 281-288. (Annales - AFPP). Colloque International sur la Biologie des Mauvaises Herbes. 12, 2004/08/31-2004/09/02, Dijon, France.

Lecunff L., Garsmeur O., Raboin L.M., Grivet L., Glaszmann J.C., D'Hont A. 2004. Construction of a sugarcane BAC contig covering the target resistance gene *Bru1* through exploitation of synteny with sorghum and rice. [Abstract W120]. [On line]. (1 p.) p. International Plant and Animal Genomes Conference. 12, ICSB Workshop, 2004/01/10-14, San Diego, California, USA. <URL: http://www.intl-pag.org/12/abstracts/W27_PAG12_120.html>.

Lejars C., Auzoux S., Legal P.Y. 2004. Organisation de l'approvisionnement des sucreries en canne : Fonctionnement et intérêt du Modèle d'Approvisionnement Global Informatisé MAGI. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (10 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 2002/10/02-05, Piton Saint Leu, Ile de La Réunion.

Martiné J.F., Todoroff P. 2004. The growth model "MOSICAS" and its simulation framework "SIMULEX". Status and perspectives. [Abstract]. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (1 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Mézino M., Chopart J.L., Combres J.C., Le Mezo L., Poser C. 2004. Estimation of the irrigation requirements of a small region based on meteorological data combined with a water balance model. Presentation of model SIMULIRRIG and an example of its use in Reunion. [Abstract]. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (2 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Poser C. 2004. La rotation banane-canne-banane : Un système de culture prometteur sur la zone de Capesterre. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (18 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Pouzet D., Chabalier P., Legier P. 2004. Fertilization of sugar cane and soil analysis: Formulationand evaluation of recommandations for small scale production system. [Abstract]. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (2 p.). (La Canne, une Passion à Partager).Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Rassaby L., Girard J.C., Rott P. 2004. Effects of Sugar Cane Yellow Leaf Virus (SCYLV) on the principal cultivars of sugar cane in Reunion. [Abstract]. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (1 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Ribbes F., Bégué A., Siegmund B., Todoroff P., Autrey J.C. 2004. Potentialités de la télédétection satellitaire pour la filière canne à sucre (Projet SUCRETTE). *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (12 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Roumagnac P., Gagnevin L., Gardan L., Sutra L., Manceau C., Rott P., Pruvost O. 2004. Caractérisation polyphasique des *Xanthomonas* isolés d'oignon, d'ail et de ciboule. In Résumés. UMR GDPP, IBVM, INRA, Université Victor Segalen Bordeaux 2, 74 (1 p.). Rencontres Plantes-Bactéries 6, 11-15 janvier 2004, Aussois, France.

Royer M., Vivien E., Pieretti I., Gabriel D.W., Rott P. 2004. Du séquençage des gènes de biosynthèse à une structure théorique de l'albicidine, une pathotoxine produite par *Xanthomonas albilineans*. In Résumés. UMR GDPP, IBVM, INRA, Université Victor Segalen Bordeaux 2, 55 (1 p.). Rencontres Plantes-Bactéries 6, 11-15 janvier 2004, Aussois, France.

Tessier P., Dagallier J.C., Lejars C., Rondeau P. 2004. Modélisation spatiale des flux de transport de la canne entre le champ et le centre de réception. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion : SEML Reunion Museo, (15 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Todoroff P., Remond J.M., Martiné J.F. 2004. Application d'un modèle de croissance de la canne à sucre sur une exploitation sucrière : validation du modèle et optimisation d'un calendrier d'irrigation. *In* Rencontres internationales pluridisciplinaires. Les Actes. [Cd-Rom]. Piton Saint Leu, La Réunion :

SEML Reunion Museo, (15 p.). (La Canne, une Passion à Partager). Perspectives de Développement de la Canne à Sucre en Milieu Insulaire : Approches Technico-Economiques, Sociales, Culturelles. Congrès de la STASM 10, 02-05 octobre 2002, Piton Saint Leu, Ile de La Réunion.

Thesis and training reports

Caray F. 2004. Rotation bananier / canne à sucre / bananier: biodiversité et évolution écologique. Mémoire d'ingénieur, ENSAIA, INPL, 80 p.

Technical reports

Bégué A., Maraux F., Todoroff P. 2004. Mission prospective pour l'élaboration d'un projet de recherche en collaboration en télédétection à Cuba du 8 au 18 mai 2004. Montpellier, France, CIRAD, 26 p.

Bonnard F., Todoroff P. 2004. Accroissement de la productivité des cannaies. Gestion durable et viable des terroirs agricoles de Guadeloupe. Elaboration d'outils d'aide à la décision pour la filière Canne-sucre-rhum. Programme européen DOCUP 2000-2006. Contrat d'entreprise du CIRAD-CA, 2e tranche, année 2003. Programme de travaux d'appui au développement de la canne à sucre en Guadeloupe. Guadeloupe, CIRAD-CA, 9 p.

Brouwers M. 2004. Compte rendu de visite agro-pédologique dans la sole cannière de la Guadeloupe (24-26 mai 2004) : milieux morpho-pédologiques, techniques culturales et de récolte, canne sèche pas chère, compostage des écumes, analyses LAPRA. Montpellier, France, CIRAD-CA, 15 p.

Chopart J.L. 2004. Les systèmes racinaires des cultures tropicales : rôle, méthodes d'étude *in situ*, développement, fonctionnement. Document de synthèse. Saint Pierre, La Réunion, CIRAD-CA, Service gestion de l'eau, 43 p.

Chopart J.L., Le Mézo L., Mézino M. 2004. OSIRI-R^{+}. Outil Simplifié pour une Irrigation Raisonnée et Individualisée avec rationnement. Présentation de l'outil et notice d'utilisation. Saint Pierre, La Réunion, CIRAD-CA, Service gestion de l'eau, 28 p.

Chopart J.L., Le Mezo L., Mézino M., Mouny Latchimy B., Nativel R., Martiné J.F., Vesoul M.P. 2004. Canne à sucre - Connaissance de l'agro-climat pour l'irrigation, la gestion du risque environnemental, la production. *In* Rapport annuel 2003 CIRAD Réunion. Saint-Denis, La Réunion, CIRAD, pp. 9-12.

Costet L., Pruvost O., Gagnevin L., Laurent P., Jouen E., Humeau L., Roumagnac P., Soustrade I., Elbaz M., Luisetti J., Delatte H., Lett J.M. 2004. Protection des plantes - Epidémiologie des maladies bactériennes et virales. *In* Rapport annuel 2003 CIRAD Réunion. Saint-Denis, La Réunion, CIRAD, pp. 52-58.

Daugrois J.H., Champoiseau P., Boisne Noc R., Joseph S., Siegwart M., Edon C., Efile J.C., Coupan J.M., Carmel S. 2004. Amélioration variétale et production de plants assainis de canne à sucre en Guadeloupe. Maladies de la canne à sucre. Rapport d'activités. Programme européen DOCUP 2000-2006. Programme de travaux d'appui au développement de la canne à sucre en Guadeloupe. Contrat d'entreprise du CIRAD-CA, 2e tranche, année 2003. Guadeloupe, CIRAD-CA, 32 p.

Girard J.C. 2004. Bactérie proche de *Xanthomonas vasicola* pv. holcicola. Référence : CAS-b4. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 4 p.

Girard J.C. 2004. *Glomerella tucumanensis* (Spegazzini) von Arx and Mueller. Référence : CAS-c1. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 4 p.

Girard J.C. 2004. *Leifsonia xyli* subsp. *xylil*. Référence : CAS-b1. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 25 p.

Girard J.C. 2004. *Xanthomonas axonopodis* pv. vasculorum. Référence : CAS-b3. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 5 p.

Goebel R. 2004. Rapport annuel d'activités. Année 2003. Projet Protection de la culture de canne à sucre. Mount Edgecombe, Afrique du Sud, CIRAD-CA, 7 p.

Goebel R., Conlong D., Way M. 2004. Notes de mission à Maurice et à la Réunion du 5 au 16 octobre 2004. Actions de coopération régionale entre la Réunion et l'Afrique du Sud dans le domaine de la protection de la canne à sucre contre les bioagresseurs. Perspectives dans le cadre plus large. Montpellier, France, CIRAD-CA, 7 p.

Goebel R., de Taffin G. 2004. Bilan du projet de coopération entre la région Réunion et la province du Kwazulu-Natal en matière de lutte intégrée contre les ravageurs des plantations de canne a sucre : Perspectives dans le cadre plus large de l'Afrique australe. Afrique du Sud, CIRAD -CA, 6 p.

Langellier P. 2004. Compte-rendu de mission au Mexique du 15 au 26 mars 2004. Montpellier, CIRAD-CA, 13 p.

Lejars C. 2004. Canne à sucre - Amélioration de l'organisation des structures de production et de prise de décision. *In* Rapport annuel 2003 CIRAD Réunion. Saint-Denis, La Réunion, CIRAD, pp. 13-15.

Marion D. 2004. Réseau ouest et cenre africain pour l'amélioration variétale de la canne à sucre. Compte-rendu de mission à Sucrivoire - Station de Zuénoula en février 2002. Montpellier, France, CIRAD-CA, 20 p.

Marion D. 2004. Réseau ouest et centre africain pour l'amélioration variétale de la canne à sucre. Compte-rendu de mission à Sucaf, station de Ferké, février 2002. Montpellier, France, CIRAD-CA, 21 p.

Marion D. 2004. Réseau ouest et centre africain pour l'amélioration variétale de la canne à sucre. Compte rendu de mission à Sucrivoire, Station de Borotou, février 2002. Montpellier, France, CIRAD-CA, 29 p.

Marnotte P. 2004. Expérimentation désherbage de la canne à sucre : rapport de mission à La Réunion du 29 novembre au 21 décembre 2003. Montpellier, Cirad-CA, 41 p.

Marnotte P. 2004. Expérimentation sur les herbicides et enherbement en culture de canne à sucre. Rapport de mission en Guadeloupe du 18 au 25 avril 2004. Malherbologie. Montpellier, France, CIRAD-CA, 27 p.

Marnotte P. 2004. Rapport de mission au Sénégal auprès de la Compagnie Sucrière Sénégalaise du 20 mars au 3 avril 2004. Malherbologie. Applications des produits herbicides. Formation et propositions d'amélioration. Montpellier, France: Cirad, 36 p.

Martiné J.F. 2004. Rapport de mission au Brésil du 24 août au 2 septembre 2004. Mission d'appui thèse de C. Suguitani et Master de P. Laclau. Relance des collaborations avec l'ESALQ et le CTC. Montpellier, France, CIRAD-CA, 12 p.

Oriol P., Roques D., Cayeux S., Coupan J.M., Efile J.C., Gelabale G., Guiougou C., Joseph A., Navis P., Nudol E., Mayo S., Sapotille J., Algou G., Cadet M., Calvados O., Carbel M., Carmel S., Catan E. 2004. Amélioration variétale et production de plants assainis de canne à sucre en Guadeloupe. Programme européen DOCUP 2000-2006. Contrat d'entreprise du CIRAD-CA, 2e tranche, année 2003. Programme de travaux d'appui au développement de la canne à sucre en Guadeloupe. Guadeloupe, CIRAD-CA, 87 p.

Pirot R. 2004. Compte rendu de la mission à La Réunion du 1er au 6 mars 2004. Montpellier, France, CIRAD-CA, 5 p.

Poser C., Ndemapou A. 2004. Accroissement de la productivité des cannaies. Gestion durable et viable des terroirs agricoles de Guadeloupe. Analyse de la variabilité du rendement de la canne à sucre en Guadeloupe nord Grande Terre : cas des communes de Port-Louis, Anse Bertrand et Petit Canal. Programme européen DOCUP 2000-2006. Contrat d'entreprise du CIRAD-CA, 2e tranche, année 2003. Programme de travaux d'appui au développement de la canne à sucre en Guadeloupe. Guadeloupe, CIRAD-CA, 100 p.

Pouzet D. 2004. Rapport de mission en Guadeloupe du 17 mars au 1er avril 2004. Saint-Denis, La Réunion, CIRAD-CA, 10 p.

Pouzet D., Letourmy P., Velle A., Martiné J.F. 2004. Evaluation du modèle de croissance de la canne à sucre MOSICAS à partir d'exploitations réunionnaises : éléments de simulation du rendement de parcelles d'exploitations du nord de l'île. Saint-Denis, la Réunion, CIRAD-CA, 16 p.

Pouzet D., Velle A., Jaglale V. 2004. Canne à sucre - Amélioration de la productivité et de l'environnement de la sole cannière. *In* Rapport annuel 2003 CIRAD Réunion. Saint-Denis, La Réunion, CIRAD, pp. 8-9.

Pouzet D., Velle A., Lombard H., Thong Chane A. 2004. Amélioration des itinéraires techniques de production de la canne à sucre. Bilan 2003 et perspectives du Pôle canne à sucre Réunion, Projet 4 Agronomie et modélisation. Saint Denis, La Réunion, CIRAD-CA, 19 p.

Raboin L.M., Dintinger J., Delatte H., Reynaud B., Carmeille A., Grisoni M., Roux Cuvelier M. 2004. Protection des plantes - Résistance des plantes aux bioagresseurs. *In* Rapport annuel 2003 CIRAD Réunion. Saint-Denis, La Réunion, CIRAD, pp. 63-67.

Reynaud B., Delatte H., Lett J.M., Chiroleu F., Ryckewaert P., Quilici S., Duyck P.F., Rousse P., Leroux K., Soula B., Nibouche S., Gilles J. 2004. Protection des plantes - Dynamique des populations et comportement des ravageurs et de leurs auxiliaires. In Rapport annuel 2003 CIRAD Réunion. Saint-Denis, La Réunion, CIRAD, pp. 58-63.

Rott P. 2004. Phytoplasme du rabougrissement de Ramu (« Ramu stunt ») de la canne à sucre. Référence : CAS-d1. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 4 p.

Rott P. 2004. Rapport de mission en pathologie de la canne à sucre en Guadeloupe du 4 au 12/06/2004. Montpellier, France, CIRAD-CA, 20 p.

Rott P. 2004. Rapport de mission en pathologie de la canne à sucre en Guadeloupe du 10 au 15/03/2004. Montpellier, France, CIRAD-CA, 16 p.

Rott P. 2004. *Sorghum mosaic virus*. Référence : CAS-v1. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 26 p.

Rott P. 2004. *Sugarcane streak mosaic* virus. Référence : CAS-v3. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 26 p.

Rott P. 2004. *Sugarcane streak virus, Sugarcane streak Egypt virus* and *Sugarcane streak Mauritius virus*. Référence : CAS-v4. *In* Mourichon X., (coord.), Camou R.,(coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 4 p.

Rott P. 2004. *Sugarcane yellow leaf virus*. Référence : CAS-v5. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 26 p.

Rott P. 2004. *Xanthomonas albilineans*. Référence : CAS-b2. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phyto-

sanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 30 p.

Rott P., Girard J.C. 2004. *Sugarcane mosaic virus* (SCMV). Référence : CAS-v2. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 28 p.

Vercambre B. 2004. *Castniomera licus*. Référence : CAS-a1. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 27 p.

Vercambre B. 2004. *Chilo partellus*. Référence : CAS-a2. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 35 p.

Vercambre B. 2004. *Diatraea centrella*. Lépidoptères. Chenille foreuse des tiges de canne à sucre. Référence : CAS-a3. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 6 p.

Vercambre B. 2004. *Eldana saccharina*. Référence : CAS-a4. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 41 p.

Vercambre B. 2004. *Eoreuma loftini*. Référence : CAS-a5. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 28 p.

Vercambre B. 2004. *Heteronychus licas*. Référence : CAS-a6. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 33 p.

Vercambre B. 2004. Mise en oeuvre d'une recherche sur la biodiversité fonctionnelle en milieux cultivés. Rapport de mission à la Guadeloupe (7 au 23 mars 2004). Montpellier, France, CIRAD-CA, n.p. 24 p.

Vercambre B. 2004. *Perkinsiella saccharicida*. Hémiptères. Cicadelle de la canne à sucre. Référence : CAS-a7. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 8 p.

Vercambre B. 2004. *Phyllophaga smithi*. Référence : POL-a1. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 29 p.

Vercambre B. 2004. Rapport de mission à l'Ile de La Réunion du 15 juin au 17 juillet 2004. Suivi du développement de la lutte microbiologique contre *Hoplochelus marginalis* (col: Melolonthinae) à l'aide de *Beauveria brongniartii (Deuteromycotina, Hyphomycete) [Rapport : Rapport de mission]*. Montpellier, France, CIRAD-CA, 20 p.

Vercambre B. 2004. Recherches sur les vers blancs à La Réunion : résultats des prospectives 2003, projet R et D 2004-2006, protocole franco-mauricien. Rapport de mission à l'île de la Réunion du 29/11 au 4/12 et du 19 au 24/12/2003. Montpellier, France, CIRAD, 18 p.

Vercambre B. 2004. *Saccharosydne saccharivora*. Hémiptères. Cicadelle antillaise de la canne à sucre. Référence : CAS-a8. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 6 p.

Vercambre B. 2004. *Sesamia inferens*. Lépidoptères. Chenille foreuse des tiges de canne à sucre. Référence : CAS-a9. *In* Mourichon X., (coord.), Camou R., (coord.), Ehret P., (coord.). Analyses de risques phytosanitaires. Appui à la rédaction de la réglementation spécifique aux départements d'outre-mer. [CD-Rom]. Montpellier, France, CIRAD, 8 p.

Vercambre B. 2004. Suivi du développement de la lutte microbiologique contre *Hoplochelus marginalis* (Col : Melolonthinae) à l'aide de *Beauveria brongniartii* (Deuteromycotina, Hyphomycete) : rapport de mission à l'île de la Réunion du 15 juin au 17 juillet 2004. Montpellier, France, CIRAD-CA, 30 p.

Way M., Conlong D., Goebel R. 2004. Visits to Mauritius and Reunion Islands 5 - 16 October 2004. Executive summary. Afrique du Sud, CIRAD, SASRI, 5 p.

Consultations and visits in 2004

Brouwers M., Guadeloupe, mai 2004. Examen de la rotation canne - banane, des techniques de récolte, visite d'essais et de champs de canne à Grande-Terre et de l'unité de compostage de la SOFUNAG

Brouwers M., Guadeloupe, mai 2004. Visite de la sole cannière de Marie-Galante

Brouwers M., Guyane, septembre 2004. Expertise analyses de sol et foliaires dans le cadre du FEOGA

Brouwers M., Soudan, octobre 2004. Recherche conventions

Brouwers M., Soudan, octobre 2004. Expertise hydro-agro-pédologique pour l'agro-épuration d'effluents (résultats confidentiels)

Chopart J.-L., Sénégal, avril 2004. Formateur d'une formation CIRAD : RACIN'SITU, caractérisation *in situ* des racines des culture annuelles et pérennes

Chopart J.-L., Brésil, novembre 2004. Collaboration avec l'UEL (Université d'Etat de Londrina) sur les études racinaires canne à sucre : séminaire, encadrement d'un thésard, projet de coopération

Chopart J.-L., France, octobre 2004. Contacts scientifiques avec 2 chercheurs du LTHE (lab. des Transferts en hydrologie et environnement) : M. VAUCLIN et J.P. LAURENT en relation avec les travaux en cours à La Réunion

Chopart J.-L., France, octobre 2004. Participation à une réunion agro-météo INRA et Météo-France

Dagallier J.-C., Barbade, juin 2004. 28e conférence des West Indies Sugar Technologists (WIST)

Dagallier J.-C., La Réunion, novembre 2004. Solutions techniques pour limiter les dégats des engins dans les parcelles.

Dagallier J.-C., La Réunion, novembre 2004. Plantation mécanique de la canne à sucre et itinéraires techniques simplifiés

Dagallier J.-C., Réunion, novembre 2004. Mécanisation de la récolte de la canne à sucre

Daugrois J.-H., Barbade, juin 2004. Participation à la conférence WIST

D'Hont A., Etats-Unis, janvier 2004. Participation au congrès PAG XII à San Diego

D'Hont A., Chine, mars 2004. Suivi de notre collaboration avec le YSRI

D'Hont A., Maurice, avril 2004. Participation à l'atelier ICSB

D'Hont A., La Réunion, avril 2004. Participation à l'atelier ICSB

D'Hont A., Afrique du Sud, octobre 2004. Participation à l'atelier Déséquilibre de liaisons

DOMAINGUE R, Sénégal, mai 2004. Discussions avec la Compagnie sucrière sénégalaise (CSS) dans le cadre de la collaboration scientifique et technique (mise à disposition de D. MARION)

Domaingue R., Sénégal, mai 2004. Rencontre avec B. COQUELET de la SOMDIAA

Girard J.-C., Sénégal, novembre 2004. Mission d'expertise en matière de phytopathologie, à la serre de quarantaine et sur le complexe sucrier de Richard Toll, à la demande de la CSS

Langellier P., Mexique, mars 2004. Participation au colloque Les atouts de l'industrie sucrière française à Vera Cruz et contacts avec les industriels canne à sucre

Langellier P., La Réunion, septembre 2004. Mission de prospection auprès de la SASRI pour une collaboration sur la gestion de l'eau chez les petits planteurs de canne à sucre

Langellier P., La Réunion, septembre 2004. Participation à l'atelier FIRCOP sur la gestion de l'eau

Langellier P., Maurice, septembre 2004. Participation à l'atelier FIRCOP sur l'amélioration de la productivité chez les petits planteurs

Laurent S., Réunion, octobre 2004. Présentation et validation de la démarche choisie pour la thèse sur la modélisation statistique de la courbe de la richesse en sucre de la canne sur l'île de La Réunion

Letourmy P., Réunion, octobre 2004. Appui à la thèse de S. LAURENT sur la modélisation de la richesse en sucre de la canne

Marnotte P., Sénégal, mars 2004. Formation sur les applications d'herbicides

Marnotte P., Sénégal, mars 2004. Désherbage à la CSS

Marnotte P., Guadeloupe, avril 2004. Expérimentation sur les herbicides et enherbement en culture de canne à sucre

Marnotte P., Martinique, avril 2004. Désherbage de la canne à sucre en Martinique

Marnotte P., Réunion, septembre 2004. Participation au Séminaire Canne

Marnotte P., Réunion, septembre 2004. Expérimentation sur les herbicides en culture de canne à sucre

Mas L., Réunion, septembre 2004. Participation au séminaire Quelles recherches prioritaires pour l'avenir de la filière canne - sucre à l'horizon 2007-2013

Mezino M., France, octobre 2004. Prise de contact avec chercheur CIRAD, INRA, CEMAGREF et CIRAME

Mezino M., France, octobre 2004. Participation à la journée Agrométéo à l'INRA

Montange D., Soudan, mars 2004. Encadrement Thèse M. Thabit Elsayed impact de l'utilisation des écumes de sucrerie

Pauquet J., Afrique du Sud, octobre 2004. Participation à l'atelier Déséquilibre de liaisons

Pirot R., Réunion, février 2004. Programmation de l'action Appui à l'irrigation

Pouzet D., Guadeloupe, mars 2004. Préparation du programme de recherche en Guadeloupe (canne sèche à faible niveau d'intrants)

Pouzet D., Réunion, septembre 2004. Préparation et participation au séminaire Quelles recherches prioritaires pour l'avenir de la filière canne - sucre à l'horizon 2007-2013

Pouzet D., Réunion, septembre 2004. Elaboration d'un SIG pour le laboratoire d'analyse des sols de La Réunion

Pouzet D., Réunion, septembre 2004. Elaboration du programme de recherche de C. POSER (canne des hauts) et de P.F. CHABALIER (fertilisation de la canne à sucre)

Pouzet D., Sénégal, novembre 2004. Formation à Thiès dans le domaine de la fertilisation et de son pilotage

Pouzet D., Sénégal, novembre 2004. Appui à D. MARION

Raboin L.-M., France, février 2004. Manipulations au laboratoire (RFLP) dans le cadre projet de thèse

Raboin L.-M., Afrique du Sud, octobre 2004. Atelier sur le déséquilibre de liaison chez la canne à sucre avec la SASRI

Rott P., Guadeloupe, juin 2004. Appui en phytopathologie à l'équipe canne à sucre

Rott P., Guadeloupe, juin 2004. Participation au comité de thèse de P. CHAMPOISEAU

Rott P., La Réunion, décembre 2004. Appui en phytopathologie de la canne à sucre au CIRAD La Réunion

Rott P., La Réunion, décembre 2004. Bilan sur les activités en entomologie de la canne à sucre au CIRAD La Réunion

Siegmund B., Maurice, octobre 2004. Atelier FIRCOP sur la mise en place d'un projet de coopération régionale sur les différences de productivité par rapport au potentiel dans les petites exploitations cannières de la zone d'Afrique Australe et de l'océan Indien

Siegmund B., Maurice, octobre 2004. Point avec les partenaires mauriciens sur le projet télédétection SUCRETTE

Siegmund B., France, octobre 2004. Contacts CIRAD-CA Montpellier et visite J.Y. DUPRE suite au séminaire de septembre 2004 à La Réunion

Siegmund B., Maurice, décembre 2004. Clôture du projet SUCRETTE avec le MSIRI

Todoroff P., Cuba, mai 2004. Participation au congrès GEOMATICA 2004 et finalisation d'un projet de recherche collaborative en télédétection

Vercambre B., février 2004. Mise en place du stage en entomologie de F. CARAY (stagiaire ENSAIA)

Vercambre B., La Réunion, septembre 2004. Programme de recherche et développement ver blanc

Vercambre B., La Réunion, septembre 2004. Séminaire Avenir Recherche de la filière canne à sucre

Vercambre B., La Réunion, novembre 2004. Participation à un comité d'encadrement de thèse

Vercambre B., La Réunion, novembre 2004. Suivi du projet Ver blanc 2004

Visiting scientists and trainees

▸ Genome Analysis

Audebert F. (c/o A. D'Hont, J. Pauquet). Contribution au clonage positionnel d'un gène de résistance à la rouille chez le cultivar de canne à sucre R570. Université Montpellier II, stage DEA, 6 mois.

Le Cunff L. (c/o A. D'Hont). Contribution au clonage positionnel d'un gène de résistance à la rouille chez le cultivar de canne à sucre R570. Université Paris VII, thèse, 12 mois.

Kübler L. (c/o LM. Raboin). Contribution au traçage de gènes majeurs de résistance à la rouille *(Puccinia melanocephala)* chez la canne à sucre *(Saccharum spp.)*, Université de La Réunion, stage de maîtrise Valorisation chimique et biologique du végétal, 2 mois.

Miranda K. (c/o A. D'Hont). Analyse de la diversité génétique du champignon responsable de la maladie du charbon. Université de Campinas, Sao Paolo, Brésil, 1 mois.

Palama T. (c/o LM. Raboin). Contribution au traçage de gènes majeurs de résistance à la rouille *(Puccinia melanocephala)* chez la canne à sucre *(Saccharum spp.)*. Université Montpellier II, stage de licence, 3 mois.

▸ Crop Protection

Abu Ahmad Youssef (c/o P. Rott). Diversité génétique et variabilité du pouvoir pathogène du *Sugarcane yellow leaf virus,* agent causal du syndrome de la feuille jaune de la canne à sucre. Ecole nationale supérieure agronomique de Montpellier, thèse, 12 mois.

Beramis S. (c/o J. Daugrois). Caractérisation des géniteurs utilisés dans le programme de sélection de variétés de canne à sucre quant à la résistance à deux maladies systémiques causées par le SCYLV et *Leifsonia xyli* subsp. *xyli*. Université Antilles-Guyane, stage de maîtrise, 2 mois.

Caray F. (c/o J. Daugrois). Rotation bananier - canne à sucre - bananier : biodiversité et évolution biologique du milieu cultivé. INPL Nancy, stage DEA, 6 mois.

Champoiseau P. (c/o J-H. Daugrois, M. Royer et P. Rott). La diversité génétique et la biodiversité de *Xanthomonas albilineans* en Guadeloupe face à la diversité mondiale de l'agent causal de l'échaudure des feuilles de la canne à sucre. Université des Antilles et de la Guyane, thèse, 12 mois.

Edon K. (c/o J. Daugrois). Maladie des feuilles jaunes de la canne à sucre : analyse de la dissémination du virus et caractérisation de cultivars résistants au vecteur. Université des Antilles et de la Guyane, thèse, 1 mois.

Gossard C. (c/o R. Goebel). Analyses d'une base de données d'infestation du foreur *Eldana saccharina* dans toutes les régions de l'industrie sucrière sud-africaine. ENITA, stage de 3e année, 6 mois.

Oliviero A. (c/o L. Costet). Etude de la diversité biochimique et génétique des *Xanthomonas* pathogènes de la canne à sucre à La Réunion. Lycée professionnel agricole, stage BTS, 3 mois.

Renier A. (c/o P. Rott, M. Royer). Diversité génétique de *Xanthomonas albilineans* et variabilité des enzymes de biosynthèse de l'albicidine, pathotoxine produite par l'agent causal de l'échaudure des feuilles de la canne à sucre. Université de Montpellier 2, stage DEA, 6 mois.

Randriamanantsoa R. (c/o B. Vercambre). Systématique et clé de détermination des vers blancs. FOFIFA/SCRiD, Madagascar, 2 mois.

Sevetiaye Nicolas (c/o R. Goebel). Analyses d'une base de données d'infestation du foreur *Eldana saccharina* dans toutes les régions de l'industrie sucrière sud-africaine. Lycée Agricole de Saint-Paul, stage BTSA, 2 mois.

Vicaire T. (c/o M. Giner, JC. Girard). Adaptation du logiciel SISTER aux besoins de la quarantaine de canne à sucre. IUP informatique Montpellier 2, stage de maîtrise, 6mois.

Vivien E. (c/o P. Rott, M. Royer). Voies de biosynthèse, composition chimique et structure de l'albicidine, un polycétide produit par *Xanthomonas albilineans*. Université de Montpellier 2, thèse, 12 mois.

▸ Varietal Improvement

Chovino M. (c/o D. Roques). Cryoconservation d'apex de canne à sucre. Université des Antilles et de la Guyane, stage de maîtrise, 2 mois.

Douared M. (c/o P. Oriol). Application de quelques outils de sélection variétale à la canne à sucre. Université des Antilles et de la Guyane, stage de maîtrise, 2 mois.

Gelabale Marius (c/o P. Oriol). Amélioration de la canne à sucre. LEGTA de Baie-Mahault, stage BTSA, 1 mois.

Agronomy and Crop Modelling

Aabad M. (c/o J.F. Martiné). Calage du modèle Mosicas dans les conditions culturales et climatiques du Maroc (Gharb), université de Gembloux, Belgique, 1 mois.

Berg A. (c/o Lejars C.). Sucre extrait de la canne : identification des facteurs climatiques explicatifs de l'écart technique, Institut National Agronomique Paris-Grignon, stage de 2e année en césure, 6 mois.

Elsayed Thabit (c/o M. Brouwers). Identification projet de thèse. Kenana Sugar Company, Soudan, 1 mois.

Laclau P. (c/o Martiné J.F.). Calage du modèle de bilan hydrique et de l'enracinement du modèle de bilan hydrique Ceres (inclus dans Mosicas) dans les conditions culturales et climatiques du Brésil (Sao Paolo). Master d'Agronomie. Ecole : ESALQ de Piracicaba. Université de Sao Paolo, thèse, 2 ans (encadrement au Brésil sous forme de missions).

Laurent S. (c/o C. Lejars, S. Cauneille). Analyse statistique des courbes de richesse en sucre de la canne pour la gestion de l'approvisionnement d'une usine sur l'île de la Réunion. USTL Montpellier II, stage DEA, 4 mois.

Maillot L. (c/o J.L. Chopart). Estimation de la réserve en eau utile dans des sols caillouteux pour le pilotage de l'irrigation. Approches combinées physique et biologique. Stage BTS.

Papaiconomou H. (c/o Lejars C.). Evaluation de différents systèmes de paiement dans le cadre d'une réorganisation des approvisionnements d'une sucrerie : application d'une démarche de simulation au bassin de Sezela, Afrique du Sud. INAPG, stage DAA, 6 mois.

Severin Y. (c/o J.L. Chopart, R. Pirot). Analyse des pratiques d'irrigation dans les périmètres sud, ISTOM, stage de fin d'études, 5 mois.

Singh A.M. (c/o J.F. Martiné). Training in crop growth modelling applied to sugarcane. Indian Institute of Sugarcane Research, Inde, 1 mois.

Suguitani C. (c/o J.F. Martiné). : Calage du modèle Mosicas dans les conditions culturales et climatiques du Brésil (Sao Paolo). Ecole : ESALQ de Piracicaba. (Université de Sao Paolo), thèse, 3 ans (encadrement au Brésil sous forme de missions).

Victoire N. (c/o J.L. Chopart). (Agent de développement en irrigation). Suivi d'une expérimentation sur le conseil en irrigation.

Support to the Sugarcane Sector and Producers

Andrianaivo A.P. (c/o P. Marnotte). Striga et semis direct sous couverture végétale. FOFIFA, Madagascar, 2 mois.

Bappel E. (c/o B. Siegmund, A. Bégué). Apport de la géomatique au pilotage de la sole cannière réunionnaise. Université de La Réunion, thèse, 12 mois.

Ipou Ipou Joseph (c/o P. Marnotte). *Euphorbia heterophylla*. Université d'Abidjan, Côte d'Ivoire, thèse, 2 mois.

Acronyms

AAU, agricultural area in use

AFLP, amplified fragment length polymorphism

AGRIGUA, Association guadeloupéenne de recueil d'informations géographiques d'utilité agricole, Guadeloupe

Agro.M, Ecole nationale supérieure agronomique de Montpellier, France

BAC, bacterial artificial chromosome

cDNA, complementary DNA

CERF, Centre d'étude, de recherche et de formation, Réunion

cM, centimorgan

CRB, Centre de ressources biologiques

CTCS, Centre technique des cultures sucrières, France

CTICS, Centre technique interprofessionnel de la canne et du sucre, France (Guadeloupe, Réunion)

CTSR, Comité technique de suivi des récoltes

CUMA, Coopérative d'utilisation de matériel agricole en commun

DAF, Direction de l'agriculture et de la forêt, France

DEA, Diplôme d'études approfondies (prerequisite diploma for PhD), France

DOM, département d'outre-mer (French overseas departments)

ENITA de Clermont-Ferrand, Ecole nationale d'ingénieurs des travaux agricoles, France

ERIC, enterobacterial repetitive intergenic consensus

ESALQ, Escola Superior de Agricultura "Luiz de Queiroz", Brazil

EST, expressed sequence tag

ETA, entreprise de travaux agricoles

FDGDON, Fédération départementale des groupements de défense contre les organismes nuisibles aux cultures

GIS, geographic information system

GPS, global positioning system

IC-PCR, immunocapture - polymerase chain reaction

ICSB, International Consortium for Sugarcane Biotechnology

INRA, Institut national de la recherche agronomique, France

JRU BGPI, Biology and Genetics of Plant-Pathogen Interactions joint research unit, Agro.M, INRA, CIRAD, Montpellier, France

JRU PIA, Polymorphisms of Interest in Agriculture joint research unit, Agro.M, INRA, Université Montpellier II, CIRAD, Montpellier, France

JRU PVBMT, Plant Communities and Biological Invaders in Tropical Environments joint research unit, Université de La Réunion, CIRAD, Réunion

MSIRI, Mauritius Sugar Industry Research Institute, Mauritius

NDVI, normalized difference vegetation index

NRPS, nonribosomal peptide synthases

PCA, principal component analysis

PCR, polymerase chain reaction

PKS, polyketide synthases

PCSI, Projet commun des systèmes irrigués, Réunion

QTL, quantitative trait locus

RFLP, restriction fragment length polymorphism

REP-PCR, repetitive extragenic palindromic - polymerase chain reaction

RT-PCR, reverse transcription - polymerase chain reaction

SASRI, South African Sugar Research Institute, South Africa

SICA, Société d'intérêt collectif agricole

SICADEG, Société d'intérêt collectif agricole et de développement économique de la Guadeloupe

SPV, Service de la protection des végétaux, France

SUCEST, Sugarcane Expressed Sequence Tag Project (database on partial sugarcane gene sequences)

SUCRETTE, Projet de suivi de la canne à sucre par télédétection (Réunion, Mauritius, Guadeloupe)

SSR, single sequence repeat

TBIA, tissue blot immunoassay

UAG, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe

WISBEN, West Indies Sugarcane Breeding and Evaluation Network, Barbados

WICSCBS, West Indies Central Sugar Cane Breeding Station, Barbados

WIST, West Indies Sugar Technologists

YSRI, Yunnan Sugar Research Institute, China

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