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Enhancing innovative pest and disease management strategies in the sugarcane agrosystem – a report on the combined ISSCT XI Pathology and IX Entomology workshops

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Abstract Diseases and pests affecting sugarcane are considered as production constraints and their management is critical to increase profitability and competitiveness of this industry. A joint workshop bringing together the Entomology and Pathology Sections of the ISSCT was held from 14-18 September 2015 in Guayaquil, Ecuador and was an opportunity to discuss topics common to both disciplines and to share the latest research results. The theme of the Workshop was 'Enhancing innovative pest and disease management strategies in the sugar cane agrosystem'. Main topics of discussions included resistance and screening, host/pathogen/insect interaction, biosecurity, integrated pest/disease management, diagnosis, pest/disease assessment and yield losses, as well as biological control. The Keynote Address on sugarcane biosecurity fitted well with the objective of the Workshop as it was a common ground of concern for both entomologists and pathologists. Biosecurity issues also echoed well in terms of their relevance to international scientific collaboration on plant protection and there was a consensus that diseases and pest incursions could be taken up as a subject of discussion at the level of ISSCT for a synergistic approach.

Key words Biosecurity, plant resistance, biological control, integrated pest management, diagnosis

INTRODUCTION

A joint ISSCT XI Pathology and IX Entomology Workshop was held in Guayaquil, Ecuador, from 14-18 September 2015 and was hosted by the Sugar Research Foundation of Ecuador (FIADE) in association with the Sugarcane Research Centre of Ecuador (CINCAE). It was the first time that the two Sections of the ISSCT held a joint workshop and the theme of the meeting was 'Enhancing innovative pest and disease management strategies in the sugar cane agrosystem'. It was an opportunity to exchange information and knowledge from two closely related disciplines and discuss themes of common interest, biosecurity being particularly at centre stage. The workshop comprised 40 full presentations and 12 posters covering seven designated topics, namely, resistance and screening, host/pathogen/insect interaction, biosecurity and current status, integrated pest/disease management, diagnosis, pest/disease assessment and yield losses and finally biological control. Sixty participants from 15 countries attended the Workshop, which captured the interest of participants from start to finish.

OVERVIEW OF THE ECUADORIAN SUGAR INDUSTRY

On the first day of the meeting, R Castillo, Director of CINCAE provided an overview of the Ecuadorian sugar industry, which enabled the participants to familiarize themselves with this vibrant sector in Ecuador. Different geographical zones of sugarcane cultivation are found between approximately 3° S and 1° N and longitude 77° 30' W. Most of the production is in the lower area of the Guayas River, near Guayaquil. Other small areas of production are located in the inter-Andean valleys. The larger sugar mills of Ecuador are San Carlos (2,100,000 t cane crushed in 2014), Valdez (1,900,000 t cane crushed in 2014) and La Troncal (COAZUCAR – 1,850,000 t cane crushed in 2014). Smaller mills located in the same area are Isabel Maria, Miguel Angel and San Juan. The harvesting period of the mills is between June to December, processing on average 12.5-month-old cane. In the inter-Andean valleys, two mills, IANCEM and MALCA, crush 14-16-month-old cane from this region almost all year round (300 days). The total sugar production of Ecuador amounted to 585,000 t in 2014, while domestic consumption was at 563,800 t. Consequently, 98% of the sugar produced in Ecuador is consumed locally.

KEYNOTE ADDRESS

The keynote address entitled 'Sugarcane Biosecurity Planning: An Australian Perspective', was delivered by A Sheppard from CSIRO, Australia. Taking the sugarcane industry as example, plant biosecurity best practices adopted by Australian plant health agencies were described. Threat identification, incursion risk analysis, pathway risk analysis, surveillance detection and diagnostics strategies were focused upon. Industry biosecurity planning has been adopted for risk prioritization and for ensuring rapid response through an Emergency Plant Pest Response Deed process whereby agreement on resources to be deployed have been determined prior to any incursion. The risks and benefits were illustrated with case histories from some recent plant pest and disease incursions into Australia. Novel areas of risk analysis that are being explored in plant biosecurity planning in Australia were described. There was general consensus that biosecurity is critical to the sustainability of the sugar industry and the experience developed in Australia could be further explored at the ISSCT level.

RESISTANCE AND SCREENING

Results from the Canal Point Sugarcane Development Program, USA, showed that brown rust resistance in Canal Point clones was mostly due to the presence of the *Bru*1 gene. Evaluation of non-*Bru*1 resistant clones in the CP Program was underway to find other durable brown rust resistance genes. Research in USA also highlighted how breeding efforts were complicated by the joint presence of brown rust (*Puccinia melanocephala*) and orange rust (*Puccinia kuehnii*). With the identification of the *Bru*1 resistance gene, breeders were able to make progress in breeding for more durable resistance to brown rust. However, with the arrival of orange rust in Florida in 2007, new promising cultivars were observed to be susceptible to this new disease. In 2014, nearly 90% of the sugarcane crop area in Florida was rated as susceptible to either one or both of the rusts. Brazil presented a generalized linear mixed model for the evaluation of sugarcane families for resistance to brown rust and a breeding programme that successfully obtained resistant genotypes to both rusts.

Studies conducted by Sugar Research Australia (SRA) showed that *Erianthus arundinaceus* and *Saccharum spontaneum* are sources of resistance to root knot (*Meloidogyne javanica)* and lesion nematodes (*Pratylenchus zeae)*. The average levels of resistance tended to decrease with successive backcrosses between the wild species and commercial hybrids. Crosses with wild species from China indicated that new resistance traits against nematodes and diseases could be conferred. A technique was developed by SRA in Papua New Guinea (PNG) for a reliable method to screen Australian varieties against the moth borers *Chilo terrenellus* (RQ117 and Q127) and *Scirpophaga excerptalis* (Q219 and Q135) in a shade house. Q219 sustained more *S. excerptalis* damage compared to Q135, which is consistent with field results. For *C. terrenellus*, RQ117 had more dead hearts compared to Q127, but Q127 had more larvae and pupae and heavier insect weights.

HOST/PATHOGEN/INSECT INTERACTION

Research in South Africa was conducted to understand the thermal tolerance of insects and water balance that could provide insights into activity and survival constraints which, in turn, would help to develop integrated management strategies. These characteristics were used to understand range expansions of *Eldana saccharina* into cooler southern African environments.

Five papers on *Sugarcane yellow leaf virus* (SCYLV) were presented during the Workshop, indicating that the virus was still one of the most widely studied sugarcane viruses. Two papers were reported under this section. In Hawaii, the use and comparison of detection methods such as tissue blot immunoassay (TBIA), reverse transcription-polymerase chain reaction (RT-PCR), quantitative real-time RT-PCR assay (RT-qPCR) and phylogenetic analysis of Hawaiian SCYLV isolates were carried out. Technical approaches to create transgenic sugarcane through genetic transformation and bioassays to validate the transgenic sugarcane for improved resistance or tolerance to SCYLV were discussed. Work in the USA indicated the presence of a virus which was close or identical to SCYLV in Columbia grass (*Sorghum almum*) and its identity was confirmed using TBIA and RT-PCR. Genome characterisation of this virus could shed light as to whether it is the same virus or a closely related species, which would be of relevance for future management strategies of the disease.

BIOSECURITY AND CURRENT STATUS

In recent years there have been significant concerns about the incursion of pests and diseases at regional and global levels. MSIRI, Mauritius reviewed some diseases and pests threats with emphasis on biosecurity issues of the African continent.

A presentation by CIRAD, France, dealt with the possibility of using Next Generation Sequencing (NGS)-based approaches to detect both known and unknown viruses in quarantine. The Virion-Associated Nucleic Acids (VANA) technique was applied and viruses such as SCYLV, *Sugarcane bacilliform virus* (SCBV), *Sugarcane mosaic virus* (SCMV) and *Sugarcane streak virus* (SSV) were reliably detected. In addition, a novel mastrevirus, *Sugarcane white streak virus*, was found.

Since Australia is geographically close to PNG, Ramu stunt disease is regarded as a potential biosecurity threat. SRA has made attempts to identify the causal agent and a tenuivirus is suspected to be involved. The virus has been successfully transmitted from infected plants to healthy plants using the insect vector *Eumetopina flavipes*. A RT-PCR test has been developed for detection of the virus and further sequencing work was in progress.

The causal agent of chlorotic streak of sugarcane is unknown at present. Work has reached an advance stage in Australia to show that a protozoa may be responsible for the disease. Significant progress was being achieved using NGS approach and a 7200 bp fragment has been obtained. PCR diagnostic tests based on actin and ribosomal 18S and 28S genes are available and there are indications that the pathogen may be a Cercozoa (Rhizaria supergroup) and confirmation of Koch's postulates were being implemented.

With the identification of tawny rust, which occurs in South Africa, Swaziland, Mozambique and Zimbabwe, three sugarcane rusts have now been identified around the world. SASRI, South Africa, has been working on the characterization of the fungus using an NGS-based approach. Preliminary analysis indicated that the pathogen diverged from existing *Puccinia* members and a new name will be proposed.

In Colombia, brown and orange rusts are considered as threats to the industry. Brown rust was already problematic because of past epidemics and the research efforts that had to be deployed to develop resistant cultivars. Few commercial cultivars had been affected by orange rust since its incursion in 2010. However, the high variability in soils and environments in the Cauca River Valley implied that vigilance has to be exerted to both diseases and an integrated approach for controlling them was deemed to be the best option. The breeding program of Ecuador, faced the same challenges. It used the *Bru*1 marker to identify brown rust resistance. High severity of orange rust, which reached Ecuador in 2011, has been observed only in cultivar SP79-2233, especially in 2015. Despite the increasing severity and spread of these two rusts on commercial cultivars, a positive finding was that cultivars released by CINCAE have shown resistance.

The Mexican rice borer (*Eoreuma loftini* (Dyar), Lepidoptera: Crambidae) was observed in Texas in 1979 and in Louisiana in 2008. It is a pest of sugarcane and rice. In 2012, it was discovered in Florida and is spreading naturally and by movement of infested plant material. There are concerns of its spread into the Poaceae family. Several promising resistant varieties have been identified but need further evaluation. The distribution and pest status, as well as the effectiveness of using classical biological control, insecticides, and host plant resistance to reduce the economic damage of the borer was discussed.

In 2008, *Ancistrosoma argentinum* Moser (Coleoptera: Scarabaeidae) was detected for the first time in sugarcane in Jujuy Province, Argentina. Yield losses ranging from 70% to 100% occurred. Chemical control was effected using imidacloprid, chlorpirifos, thiametoxam and teflutrin while biological control with the fungus *Metarhizium anisopliae*, and cultural practices were also attempted. The best control in terms of grub mortality was obtained by ploughing out infested fields followed by

a long fallow period (more than 4 months), crop rotation with soybean, and replanting after a minimum of 1 year after tillage.

INTEGRATED PEST MANAGEMENT

France has been investigating the use of a software known as Cogui for modeling conflicts and interactions in population dynamics. With this software, different interactions were represented as semantic graphs, and their automatic combinations revealed pest management strategies that could be developed for a specific location. The interactions concerned food webs of different insect communities and the impact of agricultural practices. This knowledge-based system could contribute in analyzing pest problems and to reach IPM solutions. A preliminary study was started in Panama to assess fauna and flora associated with the sugarcane agrosystem and to study the impact of stemborers.

Work in Ecuador showed that the leafhopper *Perkinsiella saccharicida* Kirkaldy (Hemiptera: Delphacidae) and yellow aphid, *Sipha flava* Forbes (Hemiptera: Aphididae) have caused significant damage to the crop, in cyclic or recurrent episodes. The strategy for management of both pests is based on pest assessment, resistance, preservation and increase of natural enemies, and the rational use of insecticides.

SCYLV, ratoon stunt (*Leifsonia xyli* subsp *xyli*) and leaf scald (*Xanthomonas albilineans*) are the three major systemic diseases of the Ecuadorian sugarcane industry. Three basic preventive disease management methods are carried out: genetic resistance, quarantine and healthy seed cane. Germplasm exchange is carried out through quarantine supported by serological and molecular techniques to detect the causal agents of these diseases, e.g. SCYLV has been detected in 28.6% of the imported germplasm and the virus is eliminated by meristem tissue culture. Screening for major diseases has been implemented to identify resistant cultivars and farmers are encouraged to use of healthy seed cane for their fields. Sugarcane mills form part of the preventive disease management using a healthy seed cane scheme starting with tissue culture plants to establish foundation, basic and commercial seed cane nurseries that have helped to drastically reduce incidence of the major diseases.

SCYLV was first detected in Colombia in 1998. When diagnostic techniques were first introduced, and few samples were sent for testing. With increased sampling and the shift from TBIA technique to the more sensitive RT-PCR, SCYLV incidence and prevalence in the Cauca River Valley is more accurately known. Virus titre has been shown to vary considerably across environments and different varieties according to RT-qPCR that has been developed and will be used for SCYLV quantification and resistance screening.

Disposal of large volumes of fungicides present an environmental concern in Australia, so a systemic fungicide, flutriafol, was shown to be at least as effective against smut as registered fungicides when used as a fungicide dip. When applied by spraying from a mechanical planter, smut incidence and severity were reduced in the early crop stages, resulting in improved cane yields. The fungicide also offered some protection against pineapple sett rot.

Sugarcane weevil borer, *Acrotomopus atropunctellus* (Boheman) (Coleoptera: Curculionidae), has been detected across all sugarcane areas in the North-West of Argentina with increasing population densities. The weevil borer was found to have an aggregated sampling distribution, and that a fixed precision sequential sampling plan, developed using Green's model and based on a two-minute inspection of the sampling unit, is the most convenient choice for estimating its population density in sugarcane.

Satellite imagery was investigated as a method for detecting infestations over large areas of white grubs (Coleoptera: Scarabaeidae) in Australia. High spatial resolution multispectral and panchromatic satellite images were acquired in May-June, corresponding with the months when symptoms of feeding by greyback canegrubs are most visible. Images taken over three years were processed using geographic object-based image analysis (GEOBIA). Results indicated that disturbances within cane fields could be detected by very high resolution imagery. However, specifying the type of disturbance such as cane grub damage was more difficult because other problems such as water-logging, pig damage, or weed infestation appeared similar.

A survey of the longhorn beetle, *Dorysthenes buqueti* Guerin (Coleoptera: Cerambycidae), a major pest in Thailand, to determine species distribution in sugarcane fields showed that it was found in all commercial sugarcane regions. The green muscardine entomopathogen, *Metarhizium anisopliae* was particularly effective against this beetle.

DIAGNOSTICS

Leaf scald, for which latent infections are common, requires efficient diagnostic tools. At the University of Florida, LAMP (loop-mediated isothermal amplification), PCR and selective isolation assays were compared. LAMP and nested-PCR detected 10 CFU/mL of the pathogen. It has been proposed that LAMP may be used as a diagnostic technique for rapid diagnosis of leaf scald in infected plants. Currently, it was not recommended to rely solely on LAMP for quarantine purposes, but rather to adopt a combination of tests.

Based on available whole sequences of seven SCYLV genotypes from Genbank, phylogenetic analysis in Mauritius revealed the presence of three clusters: BRA-PER-HAW, REU and IND-CUB-CHN1. Specific primers and probes were designed for each cluster. Three separate real-time Taqman ® RT-PCR tests were optimized and validated using 45 SCYLV infected clones to characterize the strains present. The newly developed tests proved to be specific for the intended genotype cluster and no cross amplifications were observed with non-target SCYLV genotypes. The three newly developed real-time RT-PCR tests were also more sensitive than conventional RT-PCR. For the detection of SCYLV, the use of two separate sets of primers was recommended. In Argentina, SCYLV was detected in 29 samples by RT-PCR, and was found to be widely distributed in commercial sugarcane cultivars, both in symptomatic and asymptomatic leaves. BRA-PER was the only virus genotype detected both by RT-PCR and sequence analysis of the virus coat protein gene.

Collaborative work between Cuba and Argentina was carried out to identify morphological characteristics of *P. kuehnii* isolates from Cuba and their genetic diversity using molecular techniques. New morphological features and high polymorphisms of the fungus were observed while AFLP technique allowed characterization and differentiation of the isolates. Diversity of brown and orange rusts were reported by Brazil.

Sugarcane streak mosaic virus (SCSMV) is an emerging disease of importance is South East Asian countries and is currently a threat to sugarcane worldwide, requiring that strict measures are implemented for its interception in quarantine. Australia and Indonesia have been collaborating to study SCSMV in Indonesia because of its biosecurity threat to Australia. The first objective by Australia was to develop RT-qPCR that could be used for SCSMV detection in potential vectors and in plants. Ten pairs of primers were initially designed using an alignment of full length genome sequences from Genbank. The primers were tested against a range of specimens at SRA. Results showed that the new primers could be used for a range of samples and that RT-qPCR had a higher specificity than RT-PCR. Indonesia reported several species of wild cane, weed grasses, sorghum and maize as alternative hosts of SCSMV.

In Australia, PCR primers were designed to amplify across a deletion in the Cox1 gene of the downy mildew pathogen *Peronosclerospora sacchari* with the aim of producing a species specific diagnostic test. The PCR detected three amplicon sizes from PNG specimens. Herbarium specimens and specimens from other countries were included in a phylogenetic analysis that used DNA sequences and gap coding data. The three groups were found to have been maintained, although they did not align with the defined classifications of sugarcane infecting *Peronosclerospora*. Furthermore, the variation found between specimens from PNG was greater than that of described species. It was considered that *Peronosclerospora* on *Saccharum* and *Miscanthus* in PNG required a review of its classification. It was inferred that there is a likelihood of a new species being present in PNG.

PEST/DISEASE ASSESSMENT AND YIELD LOSSES

Sugarcane moth borers are destructive insect pests of sugarcane in Thailand. Yields and net income from sugarcane between plots in which the larval endoparasitoid, *Cotesia flavipes* (Cameron) (Hymenoptera: Braconidae) was released at a rate of 1,250 adults/ha per month and control plots were compared. In treated plots, significantly higher yields were obtained resulting in higher net income.

In Argentina, sugar losses and juice degradation caused by the bacterium *Leuconostoc mesenteroides* in association with *Diatraea saccharalis* infestation was investigated. Variety TUCCP77-42 had the highest sugar loss, and increased as the harvest season progressed.

In the USA, a yield-loss study was conducted in 2013 in cultivar L01-299 affected by smut caused by *Sporosorium scitamineum*. A significant negative correlation was observed between yield of cane and sucrose and smut incidence in plant cane. A significant positive correlation between yield and smut incidence was observed on the second-ratoon crop suggesting smut was not the primary component affecting yield. Selecting seed cane from an area with low incidence of smut incidence may be important in managing smut in the variety. Another yield-loss study was established involving cultivar HoCP00-950 infected by red stripe caused by *Acidovorax avenae* subsp. *avenae*. Combined harvest data showed

a negative correlation between yield components and red stripe incidence with the strongest relationship between sucrose per tonne and disease incidence. The results suggested that red stripe may significantly affect yield of susceptible sugarcane cultivars.

In Argentina, fungicides pyraclostrobin and epoxiconazole were applied to reduce brown rust incidence and could be used to manage the disease in case cultivar resistance was compromised.

BIOLOGICAL CONTROL

Biological control was introduced in Mauritius in 1762 when the mynah bird (*Acridoteres tristis*) was brought from India to control red locusts (*Nomadacris septemfasciata*). Many examples of biological control of pests in Mauritius followed, e.g. *Phyllophaga smithi* where extensive control programs commenced and tiphiid and scoliid wasp species were introduced from Barbados, Madagascar, Java, Puerto Rico and South Africa. This approach has been adopted for the control of the stem borer (*Chilo sacchariphagus*), the shoot borer (*Sesamia calamistis*) and white scale (*Aulacaspis tegalensis*) and remain a key strategy for pest management in the country.

The population of the white grubs *Schizonycha affinis* and *Pegylis sommeri* populations have increased in sugarcane in KwaZulu-Natal. There has been great interest in developing adult and larval mycoinsecticides for these species. Microsatellite PCR primers targeting 78 isolates of *Beauveria* DNA were used to characterize the fungus. Two clusters of *Beauveria* were resolved, representing *B. bassiana* and *B. brongniartii* species groups. Virulence of the related *B. brongniartii* isolates and two *B. bassiana* isolates was evaluated in bioassays against adults and larvae of *S. affinis*, and adult *Tenebrio molitor*. Bioassays supported the finding that genetically closely related isolates may vary in their virulence, even if they were obtained from the same field epizootics, indicating host specificity.

Lack of parasitoid colonization/establishment has hampered biological control success against the stalk borer *Eldana saccharina* in sugarcane in South Africa. However, parasitoids occur on the wild hosts of the borer in wetlands sedges. Parasitoids use host plant odours and frass to locate hosts. Preliminary electrophysiological studies investigated responses of *C. sesamiae* to volatile organic compounds from sugarcane damaged by *E. saccharina*. Antennal responses suggested that host acceptance could be odour-mediated.

A project was initiated on research and development of biopesticides for white grubs (Coleoptera: Scarabaeidae) in sugarcane in the Southern Africa. All pathogens were accessioned in the South African National Collection of Fungi (SANCF) in Pretoria. Fungal isolates were used for bioassays on *Tenebrio molitor* L. beetles (Coleoptera: Tenebrionidae) at ARC-Small Grain Institute, South Africa. *Beauveria* spp. and *Metarhizium* spp. showed most potential. Post-treatment observations revealed a high rate of mortality and mycosis. The *B. brongniartii* strain BbrC17 was formulated and its efficacy was evaluated in laboratory bioassays on *Heteronychus licas* Klug and *Alissonotum piceum* Fab., in Mauritius and on *Cochliotis melolonthoides* (Gerst.) in Tanzania. However, laboratory and field assessments revealed that BbrC17 was not virulent to the local white grub species as overall mortality and mycosis were very low. South Africa and Mauritius reported the potential use of indigenous fungal entomopathogens for the control of white grubs.

BEST PRESENTATION BY A YOUNG SCIENTIST

ISSCT rewards a young scientist for best presentation at the Section Workshop with a cash prize of USD 500. For Entomology Section, the best presentation by a young scientist was awarded to Cecilia Easdale of Ledesma Sugar Mill, Argentina, for the paper 'A new pest in Argentina sugarcane fields: *Ancistrosoma argentinum'*. For the Pathology Section, the best presentation was awarded to Romina Bertani of EEAOC, Argentina, for the paper 'Morphological and molecular characterization of Cuban *Puccinia keuhnii* isolates'.

FIELD DAY: VISIT TO CINCAE AND SAN CARLOS SUGAR MILL

The workshop included a highly informative visit to CINCAE during which participants were able to learn about the different R&D activities. The breeding programme has as main objective the development of high sucrose, high cane yield varieties under lowland conditions of Ecuador. It was initiated in 1997 and the germplasm collection has 761 cultivars. Six varieties have been released and two were in semi-commercial trials. The neatly organized photoperiodic glasshouse and crossing facilities were shown to the participants.

For entomology, the two main objectives were the development of pest management technologies and support to the breeding program. The main insect pests are the leafhopper *Perkinsiella saccharicida*, the yellow sugarcane aphid *Sipha flava*, the stem borer *Diatraea saccharalis*, the silky cane weevil *Metamasius hemipterus*, and the spittlebug *Mahanarva andigena*. Studies are being carried on use of cultural control, biological control as well as a physical control measure known as crazy-cow trap, which consist of a team walking through cane fields and holding a netting to capture the leafhopper. Emphasis is laid on the development and use of fungal entomopathogens such *Beauveria bassiana* or *Metarhizium anisopliae*. However, insecticides are still used in some cases e.g for the control of persistent and high insect populations of *P. saccharicida* which is a serious pest causing up to 36% yield loss.

The objectives of the Pathology program are to provide support to the breeding program (disease screening, quarantine for germplasm exchange), (ii) maintain a clean seed cane production scheme (tissue culture/ single bud; disease diagnosis), and (iii) research on yield losses caused by diseases and epidemiology. In the screening trials, clones are evaluated to the main diseases, namely, ratoon stunting, leaf scald, brown rust, orange rust, smut, mosaic and SCYLV. Cultivars have resistance to mosaic, brown rust, orange rust and leaf scald. The healthy seedcane scheme by using tissue culture and mechanical preparation of one-eye cuttings for massive increase was demonstrated.

A field visit to plots of diseases on the 70 ha experimental station of CINCAE was of interest as participants were able to see at one spot, healthy and infected plots with diseases such as SCYLV, mosaic, ratoon stunt, leaf scald, sooty mould, brown rust and chlorotic streak. A young commercial field infested by *Perkinsiella* was also included during the visit to San Carlos Mill fields.

CONCLUSION

The Joint Pathology and Entomology Workshop was an undeniable success both in terms of its scientific contents, interactions, visits and the warmth of the Ecuadorean people. The Workshop was very well organized and planned, allowing lively discussion during the various sessions and breaks. The two disciplines had several areas of common interest, notably disease transmission by insect vectors, vector biology, integrated pest management and biosecurity. Participants were very impressed by the research facilities at CINCAE and answers to their queries receiving full explanation from CINCAE staff. The Workshop will also be remembered by participants for the cultural enrichment of the Ecuadorean way of life. The support of FIADE and staff of CINCAE in the planning and organisation of the Workshop is gratefully acknowledged.

Renforcer les strategies innovantes de gestions des insectes ravageurs et des maladies dans l'agro-systeme de la canne - un rapport du XI^{eme} atelier d'ISSCT de pathologie et du IX^{eme} atelier d'entomologie

Résumé. Les maladies et insectes ravageurs affectant la canne à sucre sont reconnus comme une contrainte à la production et leur gestion est importante pour augmenter la profitabilité et la compétitivité de cette industrie. Un atelier de travail conjoint, réunissant les sections d' entomologie et de pathologie de l'ISSCT a eu lieu du 14 au 18 septembre 2015 à Guayaquil, Equateur. C'était une occasion pour débattre des thématiques communes aux deux disciplines et de partager les toutes dernières connaissances. Le thème de l'atelier était «Renforcer les stratégies innovantes de gestions des insectes ravageurs et des maladies dans l'agro-système de la canne». Les thèmes de discussion étaient la résistance et le criblage, les interactions hôte/pathogène/insecte ravageur, la biosécurité, la lutte intégrée contre les insectes ravageurs et les maladies, le diagnostic, l'évaluation des pertes et les effets sur le rendement, ainsi que la lutte biologique. Le discours liminaire sur la biosécurité s'accordait parfaitement avec les objectifs de l'atelier de par son importance commune aux entomologistes et phytopathologistes. Le sujet avait aussi sa pertinence au niveau de la collaboration scientifique internationale pour la protection de la culture et il y avait un consensus que ce thème transversal devrait faire l'objet d'un débat à l'ISSCT pour une mise en synergie des connaissances.

Mots-clés: Biosécurité, résistance de la plante, lutte biologique, lutte intégrée, diagnostic

Ampliar estrategias innovadoras para el manejo de plagas y enfermedades en el agroecosistema de la caña de azúcar –reporte del XI taller de patologia y IX de entomologia de la ISSCT

Resumen. Las enfermedades y plagas que afectan la caña de azúcar son consideradas limitantes de la producción, y su manejo es crítico para incrementar la rentabilidad y competitividad de esta industria. Un taller de la ISSCT, llevado a cabo en Guayaquil-Ecuador del 14 al 18 de septiembre, unió las secciones de entomología y fitopatología, fue una oportunidad para discutir tópicos comunes de ambas disciplinas, y compartir los últimos resultados de investigación. El tema del taller se denominó 'Ampliar estrategias innovadoras

para el manejo de plagas y enfermedades en el agroecosistema de la caña de azúcar'. Los principales tópicos de discusión incluyeron resistencia, interacción huesped/patógeno/insecto, bioseguridad, manejo integrado de plagas/enfermedades, diagnóstico, evaluación de plagas/enfermedades e impacto en producción, al igual que el control biológico. La conferencia central sobre bioseguridad de caña de azúcar, se ajustó bien al objetivo del taller ya que fue una preocupación común fundamental de entomólogos y fitopatólogos. La discusión en bioseguridad también hizo eco en su relevancia a la colaboración científica internacional en protección de plantas y hubo consenso en que las incursiones de plagas y enfermedades podrían ser tomadas como sujeto de discusión al nivel de la ISSCT.

Palabras clave: Biosecuridad, resistencia, control biológico, manejo integrado de plagas, diagnostico