ABSTRACT BOOK

CINCAE

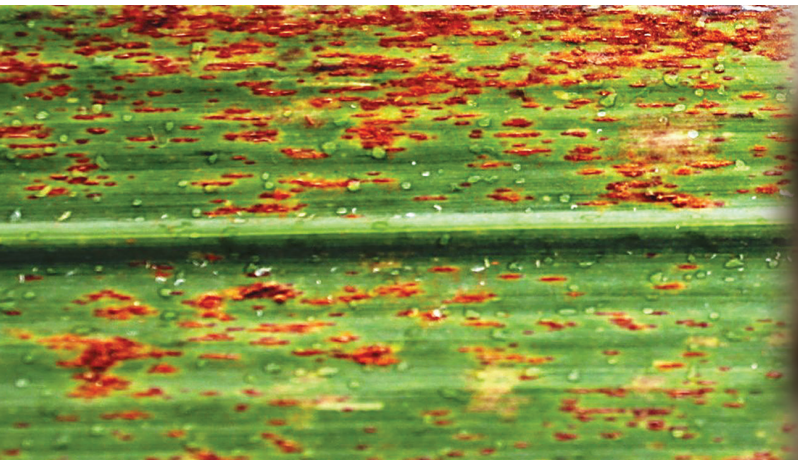
ISSCT

XI Pathology and IX Entomology Workshops

"Enhancing innovative pest and disease management strategies in the sugar cane agrosystem"

September 14-18, 2015

Guayaquil - Ecuador





XI Pathology and IX Entomology Workshops Program

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Time	Monday, Sept. 14	Code No.	Page
8:30 - 9:00	**Inaugural Session**		
	An Overview of the Ecuadorian Sugarcane Industry		1
	Resistance & screening — **Chair:** Philippe Rott **Rapporteur:** Bhuiyan Shamsul		
9:00 - 9:25	Varietal Resistance to Sugarcane Rusts in Florida: A Historical Perspective and Future Prospects. **Richard Raid, *et al.***	BP 1	6
9:25 - 9:50	Presence of *Bru*1 Brown Rust Resistance in the CP Sugarcane Development Program. **Jack Comstock, *et al.***	BP 2	7
9:50 - 10:15	Evaluation of Sugarcane Families for Resistance to Brown Rust Disease Using Generalized Linear Mixed Model. **Thiago Almeida, *et al.***	BP 3	8
10:15 - 10:40	Introgression Breeding - Source of Nematode Resistance for Australian Sugarcane Industry. **Shamsul Bhuiyan, *et al.***	BP 4	9
	Break		
	Chair: Peter Samson **Rapporteur:** Analía Salvatore		
11:00 - 11:25	Screening for Red Rot Resistance: Application of Field and Controlled Condition Testing Methods. **Rassapa Viswanathan, *et al.***	BP 5	10
11:25 - 11:50	The Role of Silicon in Plant Defense Against Insect Pests with Special Reference to Sugarcane Pests: Challenges, Opportunities and Future Directions in Sugarcane. **Amin Nikpay, *et al.***	BE 1	44
11:50 - 12:15	Novel Technique to Test for Varietal Resistance to Sugarcane Moth Borers. **Nader Sallam, *et al.***	BE 2	45
	Lunch		
	Host/Pathogen/Insect Interaction — **Chair:** Joy Zhu **Rapporteur:** Freddy Garcés		
14:00 - 14:25	*Eldana saccharina* Walker (Lepidoptera: Pyralidae) Populations and Movement-the Role of Insect Physiological Knowledge in Predicting These. **Elsje Kleynhans, *et al.***	BE 3	46

14:25 - 14:50	Whole Genome and Transcriptome Analysis of Ascomycete Pathogen *Colletotrichum falcatum* Causing Red Rot in Sugarcane to Decipher Pathogenicity Determinants. **Rassapa Viswanathan, *et al.***	BP 6	11
14:50 - 15:15	Identification of Candidate Secretory Effector Proteins (CSEPs) Genes in the Transcriptome of Red Rot Pathogen *Colletotrichum falcatum*. **Naveen Prasanth C., *et al.***	BP 7	12
	Break		
	Chair: Jean Daugrois **Rapporteur:** Carlos Angel		
15:35 - 16:00	*Sugarcane Yellow Leaf Virus (SCYLV):* Host-*SCYLV*-Vector Interaction. **Judy Zhu, *et al.***	BP 8	13
16:00 - 16:25	Is Columbus Grass (*Sorghum almum*) an Alternative Host of *Sugarcane Yellow Leaf Virus* in Florida? **Espinoza H.V., *et al.***	BP 9	14
16:25 - 16:50	Job's Tears (*Coix lacryma-jobi*) as Host of *Fiji Disease Virus* and *Perkinsiella vitiensis.* **N.S.Prasad, *et al.***	BP 10	15
19:00 - 21:00	**Welcome Cocktail**		

Time	Tuesday, Sept. 15	Code No.	Page
	Chair: Raul Castillo **Rapporteur:** Regis Goebel		
8:30 - 9:10	**Keynote Presentation:** Sugarcane Biosecurity Planning: An Australian Perspective. **Andy Sheppard**.		3
	Biosecurity & Current Status **Chair:** Nicole Thompson **Rapporteur:** Joy Zhu		
9:10 - 9:40	Pest Outbreaks and Incursions: A Non-ending Battle **Salem Saumtally, *et al.***	BP 11	16
9:40 - 10:05	Impact OFNGS-Based Diagnosis on Sugarcane Quarantine Processes. **Jean H. Daugrois, *et al.***	BP 12	17
10:05 - 10:30	Ramu Stunt: An Important Biosecurity Threat to Australia. **Kathy Braithwaite, *et al.***	BP 13	18
	Break		
	Chair: Jack Comstock **Rapporteur:** Salem Saumtally		
10:50 - 11:15	Progress in Understanding and Managing Chlorotic Streak. **Kathy Braithwaite, *et al.***	BP 14	19
11:15 - 11:40	An Update on the New Species of Rust Infecting Sugarcane in Southern Africa. L.A. **Martin, *et al.***	BP 15	20

11:40 - 12:05	In Pursuit of Sustainability: Advances and Perspectives on Sugarcane Brown Rust and Orange Rust Management in Colombia. **Carlos A. Angel, *et al.***	BP 16	21
	Lunch		
	Chair: Seelavarn Ganeshan **Rapporteur:** Gregg S. Nuessly		
14:00 - 14:25	Current Situation of *Puccinia melanocephala* and *Puccinia kuehnii Rusts* in Ecuador. **Freddy Garcés, *et al.***	BP 17	22
14:25 - 14:50	Status of the Mexican Rice Borer in the USA. **Gregg Nuessly, *et al.***	BE 4	47
14:50 - 15:15	A New Pest in Argentina Sugarcane Fields: *Ancistrosoma argentinum*. **Cecilia Easdale, *et al.***	BE 5	48
	Break		
	Chair: Freddy Garces, Jorge Mendoza		
15:45 - 16:55	**Pathology Posters Session** **Entomology Posters Session** **(Five Minutes Slides Presentation)**	BPP BEP	36-42 62-68

Time	Wednesday, Sept. 16
7:00 – 18:00	**FIELD DAY: Visit to CINCAE and San Carlos Sugar Mill**

Time	Thursday, Sept. 17.	Code No.	Page
	Integrated pest/disease management **Chair:** Mike Grisham **Rapporteur:** Sharon McFarlane		
8:30 - 9:00	Enhancing Pest Management Strategy by the Computerization of Agro-Ecosystem Interactions. **P. Martin, *et al.***	BE 6	49
9:00 - 9:25	Management Program of the Sugarcane Leafhopper, *Perkinsiella saccharicida* and the Yellow Aphid *Sipha flava* in Ecuador. **Jorge Mendoza, *et al.***	BE 7	50
9:25 - 9:50	Preventive Disease Management of Three Major Systemic Sugarcane Diseases in Ecuador. **Freddy Garces, *et al.***	BP 18	23

9:50 - 10:15	Sugarcane Yellow Leaf Virus (SCYLV): A New Old Challenge for Sugarcane Industry in Colombia. **Carlos Ariel Angel, *et al.***	BP 19	24
10:15 - 10:40	A Noble Method of Controlling Sugarcane Smut Using Flutriafol Fungicide. **Shamsul Bhuiyan, *et al.***	BP 20	25

Break

Chair: Regis Goebel **Rapporteur:** Nader Sallam

11:00 - 11:25	Optimizing a Fixed-Precision Sequential Sampling Plan for Adult *Acrotomopus atropunctellus* a New Sugarcane Pest in Argentina. **Maria Lucia Del Pilar Pérez, *et al.***	BE 8	51
11:25 - 11:50	Detection of White Grub Infestations by Satellite Imagery in The Central Cane-Growing Region of Queensland, Australia. **Peter Samson, *et al.***	BE 9	52
11:50 - 12:15	Distribution of Sugarcane Longhorn Beetle in Thailand. **Sopon Uraichuen, *et al.***	BE 10	53

Lunch

Diagnosis

Chair: Rasappa Viswanathan **Rapporteur:** Kathy Braithwaite

14:00 - 14:25	Detection of *Xanthomonas albilineans* in Sugarcane Stalks Using LAMP, PCR and Selective Isolation Assays. **Philippe Rott, *et al.***	BP 21	26
14:25 - 14:50	*Sugarcane Yellow Leaf Virus:* Specific Real-Time RT-PCR for Detection of Three Major Genotype Groups. **N. Joomun, *et al.***	BP 22	27
14:50 - 15:15	A Contribution to Improve the Understanding of the Disease Caused by *Sugarcane Yellow Leaf Virus* in Tucumán, Argentina. **Romina Bertani, *et al.***	BP 23	28

Break

Chair: Salem Saumtally **Rapporteur:** Romina Bertani

15:45 - 16:10	Morphological and Molecular Characterization of Cuban *Puccinia kuehnii* Isolates. **Romina Bertani, *et al.***	BP 24	29
16:10 - 16:35	Development of a Quantitative RT-PCR Assay for Sugarcane Streak Mosaic Virus Detection in Plants and Insects. **Nicole Thompson, *et al.***	BP 25	30
16:35 - 16:55	Variation in the Causal Agent of Downy Mildew In Papua New Guinea. **Nicole Thompson, *et al.***	BP 26	31

Time	Friday, Sept. 18.	Code No.	Page
	Pest/Disease assessment & yield losses **Chair:** Sharon Mc Farlane **Rapporteur:** Lilik Koesmihartono		
8:00 - 8:25	Economic Impact of Moth Borers on Sugar Yield in Thailand. **Wiwat Suasa-Ard, *et al.***	BE 11	54
8:25 - 8:50	Sugarcane Deterioration Caused by *Diatraea saccharalis* in Tucumán, Argentina. **Analia R. Salvatore, *et al.***	BE 12	55
8:50 - 9:15	Assessing Yield Loss Caused by Smut and Red Stripe in Sugarcane Production Fields. **Michael Grisham, *et al.***	BP 27	32
9:15 - 9:40	Sugarcane Brown Rust Control and its Effect on Yields of LCP85-384 During Four Growing Seasons in Tucumán, Argentina. **Claudia Funes, *et al.***	BP 28	33
	Break		
	Biological Control **Chair:** Desmond Edward Conlong **Rapporteur:** Sopon Uraichuen		
10:00 - 10:25	Mauritius: 250 Years of Biological Control in Sugarcane. **Ganeshan S., *et al.***	BE 13	56
10:25 - 10:50	Fungal Entomopathogens: Inter-Habitat Cycling, Genetics and Their Impacts on Sugarcane White Grubs. **Tarryn Goble, *et al.***	BE 14	57
10:50 - 11:15	Why don't Indigenous Parasitoids of *Eldana saccharina* Walker Attack its Life Stages in Sugarcane- a Breeding or Ecological Problem? **Caroline A. Okoth, *et al.***	BE 15	58
11:15 - 11:40	Pathogenicity of *Beauveria* and *Metarhizium spp.* on Tenebrio Molitor Beetles and White Grub Species in Mauritius and Tanzania. **Nalini Behary Paray, *et al.***	BE 16	59
11:40 - 12:40	**Closing**		
	Lunch		
14:00 - 14:30	**Section Business Meeting (Pathology and Entomolgy)**		

NOTES

AN OVERVIEW OF THE ECUADORIAN SUGARCANE INDUSTRY

Ecuador is one of the four smallest countries in South America, located on the west coast of the continent and is crossed by the equator (the country gets its name from the Spanish word for "equator"). It has a length of 714 km (444 mi) N-S and a width of 658 km (409 mi) E-W. Ecuador borders Colombia on the North, Peru on the East and South, and the Pacific Ocean on the West, with a total boundary length of 4,247 km (2,639 mi), of which 2,237 km (1,398 mi) is coastline. The Galápagos Islands, with an area totaling 8,010 sq km (3,093 sq mi), are approximately 1,130 km (700 mi) off the coast on the equator at 89° to 92° W. There is great variety in the climate, largely determined by altitude. It is mild year-round in the mountain valleys, with a humid subtropical climate in coastal areas and rainforest in lowlands, and the Amazon basin. The Pacific coastal area has a tropical climate with a severe rainy season from January to May between 1370 and 2000 mm of precipitation per year, and dry season from June to December. The climate in the Andean highlands is temperate and relatively dry, and the Amazon basin on the eastern side of the mountains shares the climate of other rainforest zones. Because of its location at the equator line, Ecuador experiences little variation in daylight hours during the course of a year. Both sunrise and sunset occur each day at the six o'clock hours.

Sugar production develops between approximately 3° S and 1° N of the equator and longitude 77° 30' W. Most of the production develops in the lower area of the Guayas River, near Guayaquil, in the provinces of Guayas, Los Ríos and Cañar. Other small areas of production are located in the interandean valleys of Imbabura and Loja provinces and on the coast west of players.

The larger sugar mills in the country are San Carlos, with an annual grinding of 2,100,000 t, Valdez, with 1,900,000 t, and La Troncal (COAZUCAR) with 1,850,000 t, all in 2014. Smaller mills are located in the same area, such as Isabel Maria with an average 150,000 t and Miguel Angel programed to grind a 500,000 t this year. Another mill was recently set up at the Peninsula at General Villamil Playas, Guayas, named San Juan with an approximate grinding of 400,000 t per year. All of these mills have a 12.5 months harvesting period, between June to December. In the inter-Andean valleys, in Imbabura province sugarcane mill, IANCEM grinds between 270,000 to 300,000 t and in Loja province mill, MALCA grinds between 214,000 to 250,000 t a year. These last two mills grind almost all year long (300 days), canes of 14 to 16 months. The total sugar production in the year 2014 was 585,000 MT; and domestic consumption was 563,800 t; therefore, 98% of the sugar produced is consumed in Ecuador.

There have been changes in variety composition percentages at sugar mills fields. Up to the year 2008, a single Australian variety named Ragnar occupied 89% of the variety composition, then it changed to a Colombian variety, CC85-92 with 35%, and now the new Ecuadorian varieties, ECU-01 with 30% and EC-02 and EC-03 are coming into cultivation with about 10%. The Sugar Cane Research Center (CINCAE) released these last three varieties. The remaining 25% are a mixture of introduced varieties. However, cane growers still depend on Ragnar with about 39% and CC85-92 with 49%.

It is important to mention that the Ecuadorian industry has a tonnage increase on cane and sugar production trend due to several changes. These are mainly in variety composition, use of clean seed cane in all commercial planting, agronomical practices such as two row planting, soil management using compost, filter cake and vinasse applications, improvements in fields levelling, nutrient applications, applications of ripeners, etc. In addition, sugar mills are changing from manual harvesting to 85% mechanical harvesting, e.g. Valdez mill had 96% mechanical harvesting in 2014.

As for bioenergy production, all the mills produce electricity for self-consumption. Valdez, La Troncal, San Carlos, mills have developed projects of electrical cogeneration, which goes to the interconnected stream of Ecuador. San Carlos mill can produce 50 MW, and has added new 600 and 900 psi boilers; Valdez mill, around 15-18 MW and La Troncal, 15 MW. The main alcohol production also comes from these same three largest mills. A 2014 report shows a production of 4.7 million liters of alcohol. Government projections are to replace 10% of gasoline with ethanol. In order to comply with the project Ecuador will require 237.5 million l/year by 2017.

The three mills: La Troncal, San Carlos and Valdez, through the Sugar Research Foundation of Ecuador (FIADE), decided to invest in scientific research and in 1997 created the Sugarcane Research Centre of Ecuador (CINCAE). The main objetive of CINCAE is to develop varieties adapted to the environmental conditions of the lower basin of the Guayas river and also technologies that allow the management of pests, diseases and sugarcane plant nutrition. In these first years of research, the breeding program of CINCAE has delivered six local varieties (ECU-01, EC-02, EC-03, EC-04, EC-05 and EC-06); new clones have been identified as possible varieties to be delivered in late 2015, all of them resistant to the main diseases present in Ecuador. CINCAE has also established a quarantine scheme in order to reduce the risk of diseases and insect pest introduction. In terms of technologies, CINCAE has developed a system of healthy seed cane stock production and management, starting with clean seed cane from tissue culture to deliver to the sugarcane mills for their commertial fields. Permanent diasease diagnotic services for seed cane certification is performed at sugarcane pathology laboratory to report on the seed nursery status and to make decisions on the use for commercial planting. Bioecological studies and pest management have allowed the development of technologies for ecological, economical and socially accepted recommendations. The fundamental basis for this management strategy is the monitoring and understanding of insect pest, sugarcane crop and environment interactions. Fertilization studies have determined the economic optimal dose for the ECU-01 variety and other commercial ones. Training and results transfer has been very active, carrying out several courses, workshops and seminars for sugarcane mills technical staff, and cane growers. Research results have been disseminated in technical and scientific publications.

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SUGARCANE BIOSECURITY PLANNING: AN AUSTRALIAN PERSPECTIVE

KEYNOTE LECTURE

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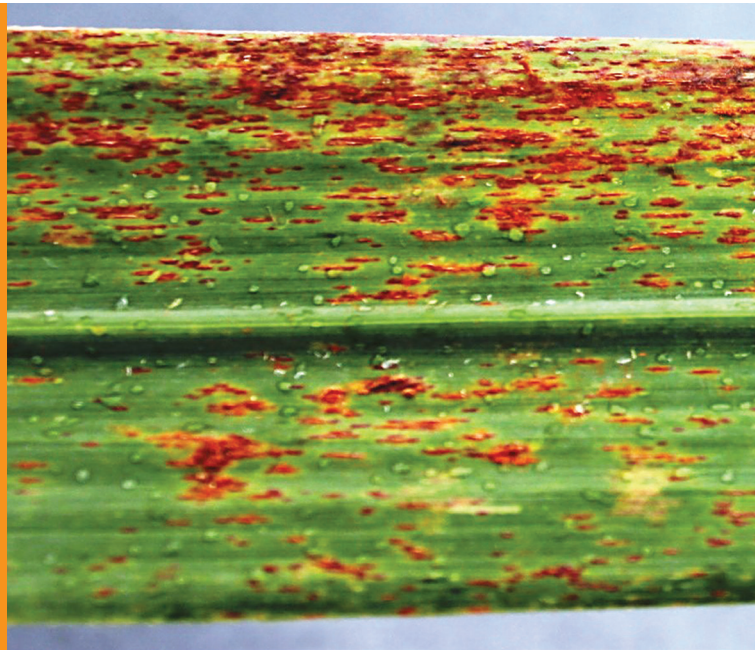
Keywords: Biosecurity, pest, disease, incursion, risk, plant health.

Effective pest and disease management in sugarcane is a critical driver of productivity and industry profitability where margins generally tend to be low. However, given international scientific collaboration on plant protection across major sugarcane growing regions of the world, there is good understanding of the major and minor global pests and diseases of this production system and where globally these occur. As a result many pests and diseases are known to be restricted in distribution and very few are yet cosmopolitan and so crop plant protection tends to be focused on managing the impacts of different suites of pests and diseases across the different regions. With growing international trade in plant products, the risks of major pests and diseases spreading between sugar cane growing regions will increase. It is widely recognized, therefore, that the industry not just focus pest and disease research on management of endemic or already present pests, but also needs to understand the risks of new pests and diseases arriving from elsewhere and how to manage those risks and potential impacts. This is plant biosecurity. In this presentation I will talk about plant biosecurity best practice adopted by Australian plant health agencies using the sugar cane industry as an example. This includes threat identification, incursion risk analysis, pathway risk analysis, surveillance detection and diagnostics strategies and industry biosecurity planning. Industry biosecurity planning has been adopted to not only for risk prioritization, but also for ensuring rapid response through an Emergency Plant Pest Response Deed process that allows agreement on who will pay for incursion response before the incursion happens based on the scale of the threat. I will illustrate the risks and benefits with some case histories from some recent plant pest and disease incursions into Australia and cover some relevant novel areas of risk analysis that are assisting plant biosecurity planning in Australia.

Dr. Sheppard is a Senior Principal Research Scientist at CSIRO. He leads or has led international collaborative research in Australia, USA, Europe and South Africa on the ecological management of national priority weeds and pests in Australia, principally using biological control. His primary research interests are around invasion biology. He has led three research Programs in CSIRO on invasive alien species management, plant biosecurity and terrestrial biodiversity and is currently a Research Director in CSIRO as well as being director of CSIRO's European Research laboratory in France. He sits on several national and advisory boards and has been on a number of international review panels in biosecurity and biodiversity and published several books and more than 150 research papers.

NOTES

PATHOLOGY ABSTRACTS



BP 1

VARIETAL RESISTANCE TO SUGARCANE RUSTS IN FLORIDA: A HISTORICAL PERSPECTIVE AND FUTURE PROSPECTS

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Keywords: *Puccinia melanocephala, Puccinia kuehnii*, brown rust, orange rust.

Historically, brown rust (*Puccinia melanocephala*) and orange rust (*Puccinia kuehnii*) have been two of the most destructive diseases of sugarcane in Florida. Cultivar differences in response to sugarcane rusts have been observed since the first report of brown rust in Florida during 1979. Two of the most widely planted cultivars at that time, CP63-588 and CL41-223, occupied nearly 50% of the state's sugarcane crop area and these cultivars were highly susceptible. Their phase out began almost immediately and by 1986, a newer cultivar, CP72-1210 occupied 61% of the acreage. Most likely because of occurrence of pathogenic variants in *P. melanocephala*, this formerly brown rust resistant cultivar soon succumbed to the pathogen and by 1998 was near absent from the cultivar census. Over the decades, this scenario has been repeated with numerous cultivars, but with the identification of the *Bru*1 resistance gene, breeders were able to make progress in breeding for more durable resistance to brown rust. Florida's sugarcane area covered with brown rust susceptible cultivars decreased from a high of 67% in 1987, to only 16% in 2007, and the disease situation was looking less dire. With the arrival of orange rust in Florida in 2007, the presence of this second rust pathogen has drastically complicated the sugarcane breeding effort, as new promising cultivars continue to fall to this disease. As of 2014, nearly 90% of Florida's sugarcane crop area was rated as susceptible to either one or both of the rust diseases. While host-plant resistance to sugarcane rusts remains the ultimate goal, there is evidence that, in Florida, physiological variants or races of both sugarcane rusts will make this goal a moving target, presenting plant breeders with a huge challenge in the coming years.

BP 2

PRESENCE OF *BRU*1 BROWN RUST RESISTANCE IN THE CP SUGARCANE DEVELOPMENT PROGRAM

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Keywords: brown rust; resistance; *Bru*1; cultivar development

Brown rust, caused by *Puccinia melanocephala,* is an economically important disease of sugarcane. Reported yield losses from brown rust have ranged from 10-40%. Sugarcane clones in the Canal Point Sugarcane Cultivar Development Program (CP Program) have been selected for brown rust resistance since the introduction of this pathogen in Florida in 1978. The CP program has different stages of development and rating for rust resistance is initiated in Stage 1, the first clonal stage, with approximate 15,000 clones. The progression of advancement is: 1,500 clones to Stage 2; 135 clones to Stage 3; 40 clones to Stage 3 increase and 13 clones to Stage 4. Clones in Stage 1 are only evaluated by natural infection; clones in subsequent stages may also be evaluated by artificial inoculation of the leaf whorl. Although the Stage 2 clones are evaluated for presence of the *Bru*1 a brown rust resistance gene, yield is the primary criteria of advancement; however, the presence of the *Bru*1 gene has increased dramatically. Clones in Stage 1 are rated for their rust reaction on a scale of 0 to 4. Clones with a rating 0 and 1 are considered resistant; results show that in 2010, 40% of the clones rated as rust resistant in Stage 1 and advanced to Stage 2 had the *Bru*1 gene. Similarly, 31, 48, and 56% of the clones rated as rust resistant in Stage 1 and advanced to Stage 2 in 2011 (CP11 series), 2012 (CP12 series) and 2013 (CP13 series) had the *Bru*1 gene, respectively. Percentage of clones with the *Bru*1 gene increased in the later stages of the CP Program. Respectively, 78, 80 and 77% of the CP10 series clones had the *Bru*1 gene in Stage 3 in 2011, Stage 3 increase in 2012 and Stage 4 in 2013. Similar trends were observed with the CP11, CP12 and CP13 series. Of the 14 CP clones released in years 2011-2014, 50 % had the *Bru*1 gene. However, of the 3 clones being considered for release this year all have the *Bru*1 gene. In 2011, one third of the cultivars in the Canal Point nursery and parental lines had the *Bru*1 gene. Although presence of the *Bru*1 gene in parents is not a primary criterion in cross selection, results show that brown rust resistance in Canal Point clones is mostly due to the presence of the *Bru*1 gene. Further evaluation of non-*Bru*1 resistant clones in the CP Program is underway to find another durable brown rust resistance gene.

BP 3

EVALUATION OF SUGARCANE FAMILIES FOR RESISTANCE TO BROWN RUST DISEASE USING GENERALIZED LINEAR MIXED MODEL

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Keywords: *Saccharum* ssp., phenotypic data, disease resistance, multi-experimental trials

Sugarcane (*Saccharum* spp.) is a complex autopolyploid with high potential for biomass production, which can be converted into sugar and ethanol. Genetic improvement is extremely important to generate more productive and disease resistant cultivars. Families of sugarcane from cultivar improvement programs are generally evaluated for several traits simultaneously and in multi-experimental trials (MET). In this study, we performed phenotyping of two families of sugarcane named SR1 and SR2 (SR1 - SP80-3280 × RB835486; SR2 - SP81-3250 × RB925345). Both families were evaluated in two locations (Araras-SP and Ipaussu-SP, Brazil) with three replicates through three years (plant cane, 1st and 2nd rations from 2011 to 2013) for resistance to brown rust disease (*Puccinia melanocephala* H. & P. Sydow) using natural infestation of the fields. Brown rust resistance was scored on the 3rd youngest leaf of each plant using diagrammatic scale according to Tai et al. (1981) and Amorim et al. (1987). A score of 1 indicates the absence of sporulating pustules (uredospores) and resistant plants. For scores from 2 to 9, the density of sporulating pustules increases and indicates susceptible plants. Five plants per plot were evaluated. The distribution of the severity data of brown rust does not follow a normal distribution, so the generalized linear mixed model (GLMM) was used for the data analysis. For modeling, probit regression was employed, and the conditional distribution of clones was considered binomial, resistant or susceptible. The analyses were conducted in the 16th edition of GenStat based on the residual maximum likelihood (REML). The analysis of the severity data using GLMM for brown rust revealed that 66% (101) and 32% (74) of the clones in SR1 and SR2, respectively, had at least a 90% probability of being resistant. The model used in this study can be tested in other families and MET of sugarcane for an understanding of the complex relationships among traits, such as resistance disease, and environments.

BP 4

INTROGRESSION BREEDING - SOURCE OF NEMATODE RESISTANCE FOR AUSTRALIAN SUGARCANE INDUSTRY

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Keywords: Nematode, resistance, germplasm.

Root knot (*Meloidogyne javanica)* and root lesion (*Pratylenchus zeae)* nematodes are the most important nematode pests of sugarcane in Australia, causing in excess of A$82 million losses to the Australian sugar industry annually. Currently no commercial sugarcane cultivars are resistant to these nematodes. A collaborative introgression program with Chinese institutes has used new sources of germplasm, *Erianthus arundinaceus* and *Saccharum spontaneum* clones to generate over 100 new families. From 2011 to 2013 approximately 400 clones from different introgression families have been screened in a glasshouse for resistance to *M. javanica* and *P. zeae*. The initial nematode population used for inoculation of test clones (Pi) and final population recovered after 12 weeks (Pf), were used to determine the multiplication factor (MF) =Pf/Pi, which is a measure of the resistance levels of test clones. For both nematodes, the lowest multiplication factors were observed on basic *E. arundinaceus* (MF = 3 - 7) and *S. spontaneum* (MF =1.8 - 6) clones, indicating moderate to high levels of resistance. Average levels of resistance tended to decrease with successive backcrosses between the wild species and commercial sugarcane. However, approximately 30% of backcross-three (BC3) populations of *E. arundinaceus* showed moderate resistance (MF≤10) to root knot and lesion nematodes compared to commercial cultivars Q208 (MF 14 - 42) and Q135 (MF 24 - 44). For backcross-two (BC2) *S. spontaneum* populations, 5% and 30% of clones had moderate levels of resistance (MF≤10) to lesion and root knot nematodes, respectively. Individual nematode-resistant clones will be further tested in the field to verify the glasshouse tests, and may prove to be a useful source of resistance to nematodes for commercial production or as parents for further breeding. New introgression clones will also be screened in coming years.

BP 5

SCREENING FOR RED ROT RESISTANCE: APPLICATION OF FIELD AND CONTROLLED CONDITION TESTING METHODS.

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Keywords: Screening for red rot resistance, field method, controlled condition screening

Red rot caused by *Colletotrichum falcatum* is a destructive pathogen and the disease impairs cane yield and juice quality. Currently cultivars with red rot resistance alone are recommended for commercial cultivation. Sugarcane progenies are screened for red rot resistance during different stages of selection process. Under field conditions, the progenies were screened by a plug method of inoculation. Since there were concerns on the injury caused in this method of inoculation, a whorl method of inoculation referred as nodal method had come into existence. However, in this method the disease development was influenced by the prevailing environmental conditions. Recently a modified nodal method was developed and it was found to be ideal for disease development through nodes as compared to the whorl method of inoculation. Further we have developed a rapid screening technique for red rot under controlled conditions to screen large number of progenies. In this method, 6-8 months old cut canes were inoculated and kept inside a high humidity chamber. Here, disease reactions are assessed in 7-10 days and this method was found ideal to screen large population of sugarcane progenies in a short period of time.

BP 6

WHOLE GENOME AND TRANSCRIPTOME ANALYSIS OF ASCOMYCETE PATHOGEN *COLLETOTRICHUM FALCATUM* CAUSING RED ROT IN SUGARCANE TO DECIPHER PATHOGENICITY DETERMINANTS

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Keywords: Red rot, genome analysis, next generation sequencing, protein-coding genes.

Colletotrichum falcatum Went (*Glomerella tucumanensis* [Speg.] Arx & Muller), an ascomycete pathogen that causes red rot in sugarcane, is a major production constraint in India and other Asian countries. Unlike other *Colletotrichum* species, which generally infect fruits and leaves, this pathogen is specialized to infect sugarcane stalks. Besides, sugarcane is the only known host for this hemibiotrophic fungus. Understandings on molecular aspects of red rot inheritance were limited because of the complexity of sugarcane genome and emergence of new virulent strains of *C. falcatum*. With the advent of Next generation sequencing (NGS) technology, the whole genome (WGA) and whole transcriptome analysis (WTA) of *C. falcatum* was performed on Illumina HiSeq 2000 platform (2x100 bp library) with more than 100x coverage. The highly repetitive ~48.2 Mb genome and ~27Mb transcriptome assembly contained abundant transposable elements (TEs), making up approximately 20% of the genome. We predicted 12,270 protein-coding genes of which 9891 genes are annotated and 2379 are unannotated as well as abundant dynamics of transcripts encoding stress and defense related proteins. Global view of syntenic alignments between the genome and transcriptome of *C. falcatum* leads to linkage group of *C. graminicola* with about 93% similarity in base pairing and gene clustering, the maximum hit obtained and sharing genes is around 90% with *C. graminicola*; notably, there is a near absence of homologous sequences among the genomes. The WGA and WTA resulted in nearly all subunits of the protein complexes like carbohydrate metabolism, putative proteins (characterized and uncharacterized), respiratory electron transport chains, the V-ATPase, and the ubiquitin–proteasome systems. Further, prediction and functional characterization of novel (class of) genes are in progress. This information will decipher the pathogenicity determinants of *C. falcatum,* understanding pathogen variability, and thereby host-pathogen interaction. This is the first attempt to decipher detailed genomic information from this sugarcane pathogen, which is an enigma to sugar industry in this region.

BP 7

IDENTIFICATION OF CANDIDATE SECRETORY EFFECTOR PROTEINS (CSEPS) GENES IN THE TRANSCRIPTOME OF RED ROT PATHOGEN *COLLETOTRICHUM FALCATUM*

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Keywords: CSEPs (Candidate Secretory Effector Proteins), TMHMM (Trans Membrane Hidden Markov Model), CAZy (Carbohydrate-Active enZYme), RNA-Seq, BNS (Biotrophy Necrotrophy switch).

Prediction of putative candidate effectors is a challenging task, with multiple strategies involved in finding both classical and non-classical proteins. By identifying the pioneers of genes, we can functionally investigate the different expression patterns potentially linked with secretory system. *Colletotrichum falcatum,* is an ascomycete fungal pathogen which infects sugarcane stalk. The hemibiotrophic nature of *C. falcatum* expresses large number of secretory proteins and the secreted proteins are expected to play a significant role in host-pathogen interactions. The RNA-Seq of *C. falcatum* transcriptome were analyzed for prediction of secreted proteins. The amino acid sequences with positive SignalP prediction for signal peptide cleavage site at N-terminal region between 10–40 amino acids, 403 transmembrane regions as predicted by TMHMM, were selected as the candidate secreted proteins. The predicted secretome was also searched for similarity across all set of effectors using BLASTx. 884 classical secretory proteins were found to have signal peptides in *C. falcatum*, about. These peptides were analyzed for transmembrane domains to define the secreted proteins using TMHMM to remove proteins that are expected to be incorporated into the membrane of the fungus. The proteins that contain signal peptides and large number of transmembrane helices of about 56 genes have been derived as secretory proteins. The *C. falcatum* secretory proteins have large number of CAZy families, esterase, peptidases, proteases, cytochrome P450, transporters, proteinase and transcription factor. The finding from RNA-Seq of *C. falcatum* showed a better understanding of the functions of these proteins in the fungal pathogenicity and localized them during infection. The pathogen biology deciphered fungal cell types and the fungal gene reprograms their expression by perception of plant-derived signals triggered by effectors substantially alters the functions of *C. falcatum* cell types for enhancing pathogenicity (BNS-Biotrophy Necrotrophy switch).

BP 8

SUGARCANE YELLOW LEAF VIRUS (SCYLV): HOST-SCYLV-VECTOR INTERACTION

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Keyword: Genetic diversity, phylogenetic analysis, *Sugarcane yellow leaf virus*

Sugarcane yellow leaf virus (SCYLV) has been reported worldwide to infect sugarcane and cause significant yield losses. Traditional plant breeding, coupled with biotechnological approaches and improved detection methods, has been extensively used to increase crop yields by producing resistant cultivars. In addition, genetic diversity among SCYLV populations revealed that there are high variations among virus isolates. This variability may affect virulence, infectivity, symptom severity and transmission. In this presentation, the use and comparison of the detection methods including tissue blot immunoassay (TBIA), reverse transcription-polymerase chain reaction (RT-PCR), quantitative real-time RT-PCR assay (qRT-PCR) and phylogenetic analysis of Hawaiian SCYLV isolates will be presented; the technical approaches used to create transgenic sugarcane through transformation, and the result from several bioassays to validate the transgenic sugarcane for improved resistance or tolerance to *SCYLV* will be discussed. Fundamental research on the host-virus-vector of SCYLV in our laboratory along with multi-collaboration provided significant gains in the understanding of the physiological and molecular response of plants to SCYLV and will be highlighted in this report.

BP 9

IS COLUMBUS GRASS (*SORGHUM ALMUM*) AN ALTERNATIVE HOST OF *SUGARCANE YELLOW LEAF VIRUS* IN FLORIDA?

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Keywords: Columbus grass, host, sugarcane, *Sugarcane yellow leaf virus*, SCYLV, *Sorghum almum*, yellow leaf.

Sugarcane yellow leaf virus (SCYLV), the causal agent of yellow leaf disease, is widespread in Florida and up until now, sugarcane was the only known natural host of this virus. We tested several grasses growing near sugarcane fields for the presence of SCYLV using tissue blot immunoassay (TBIA) with antibodies raised against this virus. A total of 170 samples of corn (*Zea mays*), 23 of elephant grass (*Pennisetum purpureum*), 4 of goose grass (*Eleusine indica*), 13 of para grass (*Urochloa mutica*), and 4 of sorghum (*Sorghum bicolor*) all tested negative. However, 170 out of 489 samples (35%) of Columbus grass (*Sorghum almum*) reacted positively. Presence of a virus close or identical to SCYLV was confirmed by Reverse Transcription-Polymerase Chain Reaction (RT-PCR) in five samples of Columbus grass using primers YLS111 and YLS462 targeting the coat protein of SCYLV. The RT-PCR product will be sequenced shortly to determine the percentage of identity between the virus found in Columbus grass and the one existing in sugarcane in Florida. Additionally, transmission of the virus from Columbus grass to sugarcane needs to be verified in order to investigate the importance of this potential secondary host of SCYLV in epidemiology and control of sugarcane yellow leaf.

BP 10

JOB'S TEARS *(COIX LACRYMA-JOBI)* AS HOST OF *FIJI DISEASE VIRUS* AND *PERKINSIELLA VITIENSIS*

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Keywords: Fiji disease virus, FDV, Job's Tears, *Perkinsiella vitiensis.*

Fiji leaf gall disease is a viral disease caused by, *Fiji disease virus* (FDV). The virus is transmitted by an insect vector known as a planthopper *(*in Fiji *Perkinsiella vitiensis* Kirk.*)*. The hosts of FDV in Fiji are sugarcane (*Saccharum* interspecific hybrid) and duruka (*Saccharum edule*). Duruka is a native plant food for Fijians. Fiji leaf gall is currently managed in commercial sugarcane fields by roguing and resistant cultivars. Sugarcane cultivars are screened for resistance using an insectary-based resistance screening method. Job's tears *(Coix lacryma-jobi* L.*),* also known as wild maize, has been reported as a potential host of FDV and its planthopper vector. Job's tears has been observed to develop galls similar to the characteristic symptom of Fiji leaf gall in the field. In this study, we tested Job's tears as a host of both FDV and *P. vitiensis.* The results have shown that Job's tears did not develop symptoms of Fiji leaf gall whereas sugarcane cultivars including the cultivar, Mana, developed typical gall symptoms. Job's tears is also not a host of *Perkinsiella vitiensis.* The planthoppers did not lay eggs on Job's tears and no nymphs were observed.

BP 11

PEST OUTBREAKS AND INCURSIONS: A NON-ENDING BATTLE

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Keywords: Biosecurity, quarantine, rust, yellow leaf, mosaic, streak mosaic, virus, aphid, thrips, borer, grubs, mite, root weevil.

In recent years there have been significant concerns about the incursion of pests and diseases at regional and global levels. On the diseases front, orange rust initially confined to the Asia-Oceania region has been reported in Western Africa, North America, Central and South America countries within a span of 7 years. Tawny rust (*P. fulva* sp.nov.) is spreading in southern Africa, following its initial discovery in Swaziland in 2008. *Sugarcane yellow leaf virus* (SCYLV) first described in 1989 in Hawaii, is reported in most sugarcane growing regions worldwide. However, its dissemination went unnoticed as it had not been recognized as a disease. .The virus is genetically highly diverse with genotypes of varying virulence being reported and prompted the development of SCYLV-genotype specific diagnostic tools. *Sugarcane streak mosaic virus* (SCSMV) initially confined to the Indo-Pakistan subcontinent is now present in other Asian countries. Molecular diagnostic tests for SCSMV detection have been designed, and quarantine stations have the necessary tool for interception of the virus. Genetic shift of predominant strains of mosaic virus was observed in Louisiana and this had major implications in the sugarcane breeding strategy for the region and in diagnostics. For the insect pests new species as well as existing ones have caused outbreaks in several countries. The Nearctic Sugarcane Yellow Aphid *Sipha flava* was recorded in Morocco in 2006 and in 2013 in South Africa and it subsequently spread to Swaziland and Zimbabwe. *Eoreuma loftini*, the Mexican rice borer, has spread to Texas in 1988, to Louisiana in 2008 and to Florida in 2012. The stalk borer *Chilo sacchariphagus*, had spread into Mauritius and Réunion in the mid-nineteenth century and since 1998 severe damage and loss is being observed in Mozambique. Strict quarantine measures are in force in South Africa and Zimbabwe to prevent its entry. The sugar cane thrips *Fulmekiola serrata* present in the Indian Ocean islands was first detected in South Africa in 2004 and has now become widespread in the industry. The white grub *Hoplochelus marginalis*, indigenous to Madagascar was observed in Reunion Island in 1981 and caused severe losses to the cane industry. The tropiduchid *Numicia dorsalis* was originally described from Madagascar. In 1989, it was collected from sugarcane in Reunion Island and was first observed in 2006 in Mauritius. Several minor pests have been cause for concern in many countries e.g the sacarabeid *Ancistrosoma argentinum* which was detected in Argentina in 2008, the stalk borer *Diatraea tabernella* in Colombia in 2012, the mite *Abacarus sacchari* in Florida in 2007, and the root weevil *Diaprepes abbreviatus* in Florida in 2010. Collaboration among research centres and quarantine stations is deemed essential to prevent the incursions of systemic diseases and insect pests.

BP 12

IMPACT OF NGS-BASED DIAGNOSIS ON SUGARCANE QUARANTINE PROCESSES

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Keywords: Quarantine, Next Generation Sequencing, virus detection.

Quarantine processes are essentially performed for detecting known pathogens. In the last decade, Next Generation Sequencing (NGS) approaches have proved to be reliable methods for detecting and identifying both known and unknown viruses. The Cirad Sugarcane Quarantine (CSQ) had set up several pilot projects based on these NGS approaches aiming at evaluating their strength and reliability for sugarcane virus detection. For instance, we have used the so-called VANA (virion-associated nuclear acids) approach to detect viruses from CSQ material and CIRAD Sugarcane collection (CSC) material supplied by the Biological Resources Centre of Tropical Plants INRA-CIRAD. Leaf samples from 300 CSC and 245 CSQ cultivars were processed, respectively. Sequences generated by this study were filtered and assembled using in-house bioinformatics pipelines. Known viruses, such as *Sugarcane yellow leaf virus* (SCYLV)*, Sugarcane baciliform virus* (SCBV)*, sugarcane* infecting *streak viruses* (SSV, SSRV, SSEV) and *Sugarcane mosaic virus* (SCMV) were reliably detected using the VANA approach. In addition, several unknown viruses were found, including viruses from the *Geminiviridae* and the *Tombusviridae* families. Another virus belonging to the *Ampelovirus* genus (*Closteroviridae* family), which is likely to correspond to *Sugarcane mild mosaic virus* (SCMMV) described by B.E.L Lockhart et al. was also found in both CSQ and CSC plants. The discovery of these new sugarcane viruses stresses the need to better and dynamically adapt quarantine processes to the emergence of unknown viruses. A full characterization of these novel viruses must be carried out before figuring out whether the detection and sanitation of these novel viruses have to be included within CSQ processes. The full characterization of these novel viruses includes several complementary studies, such as virus genomics, virus epidemiology, virus detection, risk analysis and plant sanitation. This approach is already applied for a novel Mastrevirus (*Geminivridae*) and will be next extend to the other new detected viruses.

BP 13

RAMU STUNT: AN IMPORTANT BIOSECURITY THREAT TO AUSTRALIA

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Keywords: Ramu stunt, *Eumetopina flavipes*, diagnostic test, transmission, surveys.

Ramu stunt was unknown until 1985-86 when poor yields, stool death and severe stunting became evident in commercial crops at Ramu Sugar (now Ramu Agri-Industries Limited, RAIL) in Papua New Guinea. The disease is characterized by stunting, failure to ratoon and various ill-defined leaf symptoms. The vector is the island sugarcane planthopper *Eumetopina flavipes.* At the time of the epidemic, the causal agent was unknown but was suspected to be a virus or a phytoplasma. As the disease has not yet been found in Australia, but the vector has, Ramu stunt is a major quarantine risk to the Australian sugar industry. Earlier research suggested that the causal agent was a virus with homology to the genus *Tenuivirus*. A diagnostic RT-PCR test was developed but was largely untested. A recently concluded five year project has allowed SRA and RAIL to progress our understanding of the disease. Access to good quality material has allowed us to validate the diagnostic test for Ramu stunt, obtain more genome sequence information and look at genome variability across isolates. The distribution the disease was determined by carrying out disease surveys. Verification that the disease is caused by a virus was obtained from caged transmission experiments using the vector to transmit the disease, with confirmation by symptomology, RT-PCR, sequencing and protein analysis. A number of resistance screening trials were planted during the project to assess the reaction of Australian cultivars. Fortunately, the level of resistance to Ramu stunt present within the germplasm is quite high, allowing late stage selection.

BP 14

PROGRESS IN UNDERSTANDING AND MANAGING CHLOROTIC STREAK

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Keywords: Chlorotic streak, diagnostic test, Next Generation Sequencing, hydroponics.

Chlorotic streak is a major disease in Australia. It is one of the most common and widespread diseases, found in all sugarcane growing areas. It can cause serious yield losses, particularly in flood prone or waterlogged fields, where susceptible cultivars can show losses of up to 40%. Chlorotic streak disease was first recognized around 1929 but the causal agent is still unknown. Australian scientists were actively involved in chlorotic streak research in the 1960's and they concluded that the disease was caused by a virus. Other workers suggested that it was caused by a chytrid fungus. SRA resumed research in 2009 with little progress until 2012 when a DNA sequence specific for the disease was identified. This was a significant breakthrough as it formed the basis of a diagnostic PCR test. Since then, increased research efforts have led to progress in a range of activities. The diagnostic test has been refined and is used to screen field samples and monitor research experiments. Next Generation Sequencing is underway to identify the causal agent, and when combined with efforts to isolate the organism and control its transmission, Koch's Postulates may eventually be fulfilled. *In situ* hybridization is also underway to visualize the organism in sugarcane tissues. Resistance screening trials are planted in the field, and a glasshouse hydroponic system is being trialed as a better way to screen cultivars and obtain resistance data. Our understanding of the causal agent may open up new management strategies that will reduce losses and decrease the cost of existing management programs.

BP 15

AN UPDATE ON THE NEW SPECIES OF RUST INFECTING SUGARCANE IN SOUTHERN AFRICA

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Keywords: African sugarcane rust, tawny rust, *Puccinia fulva* sp. nov., Pucciniales, specific PCR, yield.

A new species of rust was observed on sugarcane in Swaziland in 2008. It has since spread to most cane-growing areas in South Africa, and more recently to fields in Mozambique and Zimbabwe. Symptoms include dark brown lesions on the lower and upper leaf surfaces developing parallel to the leaf midrib and abundant, bright orange urediniospores. Initial sequencing of the ITS and 28S nuclear large subunit (nLSU) genes revealed no identical matches on the NCBI database. Subsequent phylogenetic analyses based on the same gene region showed that this rust falls within a group of rusts genetically distinct from brown rust (*Puccinia melanocephala*), previously the only rust species known to infect sugarcane in southern Africa, and orange rust (*P. kuehnii*). Orange rust has not as yet been observed on sugarcane in the region. A collaborative study with the United States Department of Agriculture - Systematic Mycology and Microbiology Laboratory (Beltsville, Maryland, USA) involving a morphological comparison with other closely related rusts, confirmed the presence of a previously undescribed rust species infecting sugarcane in southern Africa. The study also assisted in the preparation of a morphological description of this new disease - proposed name tawny rust, caused by the pathogen *Puccinia fulva* sp. nov. This taxonomic description along with the results from a more thorough investigation into the phylogenetic placement of this species within a broader context of the Pucciniales will be presented. Other research outcomes including a specific polymerase chain reaction (PCR) assay for rapid identification of the pathogen, the results of a study on the environmental conditions favoring spore germination and tawny rust development, as well as the results of field trials investigating the effect of the disease on sugarcane yield will be discussed.

BP 16

IN PURSUIT OF SUSTAINABILITY: ADVANCES AND PERSPECTIVES ON SUGARCANE BROWN RUST AND ORANGE RUST MANAGEMENT IN COLOMBIA

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Keywords: Brown rust, orange rust, CC cultivars, epidemiology, resistance, management.

Out of approximately 450,000 hectares of sugarcane planted in Colombia, 230,000 hectares are located in the Cauca river valley, which is considered strategic for Colombia's economy. Brown rust (BR) (*Puccinia melanocephala*) and orange rust (OR) (*P. kuehnii*) diseases are permanent concerns for the industry and farmers, requiring integrated management practices for their control. Since BR's arrival in 1978 which caused epidemics in susceptible cultivars B43-62, CP57-603, MZC74-275, and Mex52-29, CENICAÑA-Colombia (CC) began breeding resistant cultivars to BR. Between 1991-1994, BR resistant cultivars CC85-92 and CC84-75 were deployed, reaching almost 90% of the area by 2009. Orange rust arrived in 2010, but affects few commercial cultivars currently. Considering the high variability in soils and environments in the Cauca valley, new BR and OR resistant cultivars have been developed for dry, humid, and foothill zones, and incorporated into a site-specific agriculture program that includes more than 30 CC cultivars. Brown rust has increased progressively on CC85-92 and CC84-75 since 2007, breaking the resistance by 2014. Brown rust is increasing on CC92-2804, CC97-7170, CC98-72, CC01-1228, CC03-154, CC03-469, and SP71-6949; however they are still considered resistant. CC01-746, CC05-940, CC97-7170, and RB73-2223 have low levels of OR, and more than 17 CC cultivars being planted remain resistant to BR and OR. Although CC85-92 and CC84-75 occupy 52% and 4.5% of the area planted in sugarcane, respectively, they are being replaced by CC93-4418 (12.5%), CC01-1940 (11.8%), and CC93-4181 (1.4%), among others. Experiments on the efficacy of different fungicides, biologicals, and fertilizers have not shown statistical differences in cane and sugar between treated and non-treated. Also, no economic impact of BR and OR has been found. The effects of BR and OR will continue to be evaluated, and integrated disease and crop management based on resistance is still the best strategy to pursue for a sustainable and competitive sugarcane industry in Colombia.

BP 17

CURRENT SITUATION OF *PUCCINIA MELANOCEPHALA* AND *PUCCINIA KUEHNII* RUSTS IN ECUADOR

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Keywords: Sugarcane rust, detection, survey, sugarcane cultivars.

The presence of two sugarcane rust diseases, brown rust, *Puccinia melanocephala,* and orange rust, *P. kuehnii*, was confirmed in the Ecuadorian sugarcane crop. Historically, brown rust has been a major disease in different countries, increasing severity in cultivars that were considered resistant. This disease was observed in Ecuador in the 1980´s affecting the susceptible cultivar B43-62. In recent years, high severity levels of brown rust have been observed only in sugarcane fields located in the Ecuadorian Andean valleys isolated from the coastal tropical area. However, at the end of the 2014 dry season, the disease was confirmed in the cultivars CC85-92 and CR74-250 which occupy 45% of the sugarcane cultivated area. Cultivar CR74-250 presented greater severity, persistence and dispersion. Additionally, clones from the selection stages in CINCAE's breeding program have shown an increase of infection. Currently, the *Bru*1 marker for brown rust resistance is being used to identify resistant cultivars at the breeding program. In relation to orange rust, reported in Ecuador in 2011, high severities and spores dispersion have been observed only in the susceptible cultivar SP79-2233, especially during 2015. Despite the presence and increase in severity and spread of these two rusts, no symptoms of susceptible infection have been observed in cultivars released by CINCAE.

BP 18

PREVENTIVE DISEASE MANAGEMENT OF THREE MAJOR SYSTEMIC SUGARCANE DISEASES IN ECUADOR

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Keywords: *Leifsonia xyli* subsp. *xyli*, *Xanthomonas albilineans*, SCYLV, control, seedcane, quarantine, resistance.

Yellow leaf, SCYLV, ratoon stunt, *Leifsonia xyli* subsp *xyli*, and leaf scald, *Xanthomonas albilineans,* are the three major systemic diseases of the Ecuadorian sugarcane industry. Surveys and studies on yield effects lead to define research and management strategies at CINCAE. At CINCAE three basic preventive disease management methods are carried out: genetic resistance, quarantine and healthy seed cane. Germplasm exchange is carried out through a controlled quarantine process supported with serological and molecular techniques to detect the causal agents of these diseases. For instance, SCYLV has been detected in 28.6% of the imported germplasm. This virus and any potential diseases are eliminated using meristem tissue culture ensuring a clean material to incorporate in the sugarcane germplasm collection of CINCAE. In addition, screening of diseases infection has been developed to identify resistant materials and encourage farmers on the use of healthy seed cane for commercial fields. Recently, the use of the molecular technique qPCR has been explored to confirm the resistance observed in cultivars released by CINCAE and clones in the selection program. Sugarcane mills are part of the preventive disease management using a healthy seed cane scheme starting with tissue culture plants to establish the foundation, basic and commercial seed cane nurseries. This scheme has significantly reduced the levels of incidence from 1999 to 2014; thus, ratoon stunt was reduced from 41.4 to 0.2%, yellow leaf from 36.4 to 9.8% and leaf scald from 3.0 to low levels of 0.22%.

BP 19

SUGARCANE YELLOW LEAF VIRUS (SCYLV): A NEW OLD CHALLENGE FOR SUGARCANE INDUSTRY IN COLOMBIA.

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Keywords: Sugarcane yellow leaf virus, SCYLV, importance, diagnostics, epidemiology, management.

SCYLV is one of the most prevalent pathogens in sugarcane worldwide that was detected in Colombia in 1998 by CENICAÑA. It is considered as an economically important disease, due to its variable effects, its difficulty to be diagnosed by symptoms, and its transmission by aphids and infected seed setts. Screening of nurseries and commercial fields has been done by Tissue Blot Immuno-Assay from 2000 to 2006, and Reverse Transcription PCR since 2009 to present, measuring SCYLV incidence (% of infected plants within a composed sample), and prevalence (% of infected samples). A 1998 survey at the Cauca river valley showed virus incidence of 8.6%, 1.0% and 0.3% at the South, Central and North regions. Following studies found different levels of resistance in a set of 24 cultivars including CC 85-92, and other studies showed economic impact in some, including CC 84-75, but still they were widely planted. Analyzed samples at the lab increased from 677 in 2000 to 2,260 in 2014. Highest SCYLV prevalence occurred during 2014, 2003 and 2004 with 22.7%, 21.6% and 20% respectively, and incidences were 4.5%, 8.7%, and 3.1% respectively. Based on geographical analysis, most infected and healthy sampled fields were located, confirming the wide distribution along the valley, with higher prevalence in the Southern regions. Almost all cultivars planted through the years have been infected; in 2014 higher prevalence was found in RB 73-2223 (54.4%), SP 71-6949 (50%), CC 84-75 (40%), and CC 01-1940 (39.3%); however, economic impact studies on newly planted cultivars are still in progress. Real time PCR has been developed to detect SCYLV, and it is being adapted for virus resistance studies based on quantitation of virus titers and accumulation curves. Based on these results, CENICAÑA promotes planting only tested healthy seed to keep SCYLV under potential economic impact in Colombia.

BP 20

A NOBLE METHOD OF CONTROLLING SUGARCANE SMUT USING FLUTRIAFOL FUNGICIDE

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Keywords: *Sporisorium scitamineum*, smut, control, fungicide.

Sugarcane smut, caused by *Sporisorium scitamineum*, is one of the most devastating diseases of sugarcane worldwide. Triazole fungicides, propiconazole and triadimefon, are registered to be used as dip treatments to protect seed-cane from infection with sugarcane smut. However, there are some drawbacks with the dip treatments, it can only be applied to mother stock planting materials because of the logistics of dipping large quantities of seed-cane, and it is difficult to dispose large volumes of waste fungicide solution in an environmentally safe manner. There was an urgent need for a new fungicide, which are more systemic than current registered one that can be applied using more practical methods. We evaluated the efficacy of flutriafol fungicide to control sugarcane smut using various application methods. In a 2007 experiment, flutriafol fungicide was equally effective or better in controlling sugarcane smut as a dip than were two fungicides, propiconazole and triadimefon, registered in Australia. In 2009, two experiments determined the effectiveness of flutriafol when applied by mixing with fertilizer or spraying on the seed-cane at planting. All fungicide treatments significantly suppressed smut in one experiment, but in the second one flutriafol-fertilizer mix treatments were ineffective. In 2010, two experiments at Bundaberg and Mackay verified the efficacy and effective rates of flutriafol against sugarcane smut when applied through existing spray equipment designed to spray fungicide on cuttings as they drop into the planting furrow on a commercial planter. Smut incidence and severity were reduced significantly in both experimental sites compared to the inoculated control plots. Sugar yield increased by 46-65% in Bundaberg and 157-203% in Mackay compared to the inoculated control. Previous research indicated that flutriafol also is effective in controlling pineapple sett rots of sugarcane (*Ceratocystis paradoxa* Dade, C. Moreau). There is potential to control sugarcane smut and pineapple sett rot with one application of flutriafol fungicides, which will reduce the cost of fungicide application substantially.

BP 21

DETECTION OF *XANTHOMONAS ALBILINEANS* IN SUGARCANE STALKS USING LAMP, PCR AND SELECTIVE ISOLATION ASSAYS

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Keywords: Detection, isolation, LAMP, leaf scald, PCR, sugarcane, *Xanthomonas albilineans*.

Leaf scald, caused by *Xanthomonas albilineans,* is a major disease of sugarcane that can cause severe yield losses in susceptible cultivars. The disease is mainly controlled by use of resistant cultivars that need to be screened in breeding programs. Several diagnostic techniques are currently available to identify or to detect *X. albilineans* in infected stalks, including isolation on selective medium, serological and molecular methods. Each of these methods has advantages and disadvantage in terms of time and equipment/ facilities needed, or sensitivity. In this study, we developed a colorimetric loop-mediated isothermal amplification (LAMP) assay, an easy, rapid and simple molecular method for identification of *X. albilineans*. This method requires only four specific primers, a DNA polymerase, and a regular laboratory water bath or heat block for DNA amplification. A positive reaction is indicated by a color change of the hydroxynaphthol blue (HNB) in the reaction solution from violet to sky blue. *X. albilineans* was detected by LAMP, PCR (polymerase chain reaction) and isolation on selective medium (XAS) in respectively 26, 26 and 27 out of 27 sugarcane stalks exhibiting symptoms of leaf scald in the field. The pathogen was also isolated from 33 out of 46 asymptomatic stalks using the selective agar medium. Only two of these asymptomatic stalks were found infected by *X. albilineans* using LAMP and PCR. Consequently, occurrence of pathogen stalk populations that are below the detection threshold of both LAMP and PCR limits the use of these two methods for detection of *X. albilineans* in plants showing no symptoms. However, LAMP can be used for easy and rapid identification of the pathogen in symptomatic plants or after isolation of the bacteria on agar medium.

BP 22

SUGARCANE YELLOW LEAF VIRUS: SPECIFIC REAL-TIME RT-PCR FOR DETECTION OF THREE MAJOR GENOTYPE GROUPS

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Keywords: Yellow leaf, SCYLV, genotypes.

Sugarcane yellow leaf virus (SCYLV), the causal agent of yellow leaf of sugar cane, displays high level of genetic diversity. To-date, at least 9 genotypes have been described and named according to geographic origin; BRA, PER, HAW, CUB, REU, IND, CHN1, CHN2 and CHN3. Based on available whole sequences of 7 genotypes from Genbank, phylogenetic analysis revealed the presence of three clusters; namely BRA-PER-HAW, REU and IND-CUB-CHN1. Sequences of SCYLV from these clusters were further analyzed and 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. Using these tests, 4 isolates were characterized as REU, 35 as BRA-PER-HAW, including one co-infected with IND-CUB-CHN1 and 7 as IND-CUB-CHN1. 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. One further observation, of great importance, is that primers YLS 462/111, most commonly used for SCYLV detection, failed to detect the 6 clones belonging to the IND-CUB-CHN1 cluster. Sequence analysis of reverse primer YLS 462 confirmed that the non-amplification is due to a 2 bp mismatch at 3' end for IND and CHN1 isolates. Therefore, for the detection of SCYLV, the use of two separate sets of primers is now recommended; a first test using primers YLS 462/111, followed by ScYLVf1/r1 primers.

BP 23

A CONTRIBUTION TO IMPROVE UNDERSTANDING OF THE DISEASE CAUSED BY *Sugarcane yellow leaf virus* IN TUCUMÁN, ARGENTINA

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Keywords: Virus presence-symptoms correlation, genetic diversity, SCYLV.

Yellow leaf, caused by *Sugarcane yellow leaf virus* (SCYLV), is spread worldwide; however, its incidence and distribution in Argentina remain unclear. We have limited information on disease prevalence, distribution and status of virus infection in sugarcane genotypes / parents in the country. The aims of this study were to assess SCYLV presence, characterization of the virus, its distribution in the main sugarcane production area in Argentina, and determine the correlation between virus detection and disease symptoms. For this purpose, 148 sugarcane +1 leaf samples with and without symptoms were collected in 2011 and 2012 in Tucumán province from commercial cultivars, advanced breeding clones at final testing stages of selection, and parents used in the Estación Experimental Agroindustrial Obispo Colombres (EEAOC) Sugarcane Breeding Program. One additional sample was collected in Salta, Argentina, as it is considered a different geographical and agroecological producing region. Results showed that SCYLV was detected in 29 samples by RT-PCR, including Salta sample, and was widely distributed among commercial sugarcane cultivars, both in symptomatic and asymptomatic leaves. A low but statistically significant positive correlation between virus detection and disease symptoms was found, whereas 83% of the positive samples were asymptomatic. BRA-PER was the only virus genotype detected both by RT-PCR and sequence analysis of the virus coat protein gene.

BP 24

MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF CUBAN *PUCCINIA KUEHNII* ISOLATES

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Keywords: Orange rust, AFLP, SSR, adaxial epidermis.

Orange rust (*Puccinia kuehnii*) is a widespread sugarcane disease, known to have devastating impacts on the crop. Although the most effective way to control rust diseases is the use of resistant cultivars, durability of resistance is conditioned by several factors including pathogen genetics. In Cuba, where orange rust is a relatively new disease and environmental conditions favor infection, there have not been previous studies characterizing the pathogen. The aims of this study were to establish morphological characters that could best describe and differentiate *P. kuehnii* isolates collected throughout different growing seasons and locations in Cuba, and to set an adequate molecular technique for estimating *P. kuehnii* genetic diversity. All samples showed typical lesions by *P. kuehnii*: pustules were located on the abaxial epidermis of leaves and, to a lesser degree, on their adaxial surface in some of the analyzed sugarcane genotypes. In addition, new morphological features associated with this pathogen were observed. Morphological characterization suggested that there is a single, but highly diverse and complex pathogen population, and the groups obtained showed no apparent correlation among isolates and sugarcane cultivars, locations and collection dates. With regard to molecular studies, AFLP markers successfully characterized orange rust isolates and detected a higher genetic diversity than morphological descriptors, showing a weak correlation between the isolates and their geographical origins, as well as with the sampling dates. In addition, transferability of *Puccinia melanocephala* microsatellite loci could not be observed for *P. kuehnii*. On the other hand, the sequences of rDNA regions did not show significant differences among Cuban *P. kuehnii* isolates. This work presents a thorough characterization of *P. kuehnii* isolates, including morphological traits, molecular markers and rDNA region sequence.

BP 25

DEVELOPMENT OF A QUANTITATIVE RT-PCR ASSAY FOR SUGARCANE STREAK MOSAIC VIRUS DETECTION IN PLANTS AND INSECTS

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Keywords: Diagnosis, RT-PCR, virus.

Sugarcane streak mosaic virus (SCSMV) is a virus associated with mosaic disease in sugarcane that has spread rapidly throughout Asia in recent years. In some crops, nearly 100% of the cane is infected and disease losses are relatively unknown and difficult to measure. Australia has, to this time, remained free from SCSMV; however, it is found in our neighboring countries and is therefore one of the highest priority biosecurity threats to Australia. SRA and the Indonesian Sugar Research Institute (P3GI) have embarked on an ACIAR-funded project to study SCSMV in Indonesia. This project will address modes of transmission, development of diagnostic tests, yield losses, disease resistance and surveys of Indonesia. The first aim of the diagnostic team in Australia was to develop a sensitive test that could be used for SCSMV detection in potential vectors, for plant diagnosis, analysis of viral load, etc. Quantitative RT-PCR was chosen because of the expected increased sensitivity, quantitative (or semi-quantitative) nature of the assay and the possibility of a gel-free, semi-automated analysis. The qRT-PCR can be compared to the published RT-PCR protocols to ensure that the sensitivity and specificity is good for application to field collected specimens. 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 held in the SRA Biosecurity collection. This paper will report on the development, sensitivity and application of the qRT-PCR.

BP 26

VARIATION IN THE CAUSAL AGENT OF DOWNY MILDEW IN PAPUA NEW GUINEA

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Keywords: Downy mildew, *Peronosclerospora*, diagnostics.

Downy mildew of sugarcane is a serious disease of the sugarcane industry in Papua New Guinea. Symptoms of downy mildew are readily found on commercial cane, wild *Saccharum* species, garden cane, *Miscanthus* and corn in PNG. There are two main leaf symptoms: streaking and shredding. The classic leaf streaking symptoms are white/red streaks on the leaf that produce a characteristic down (conidia and conidiophores) on the underside of the leaf in favourable night-time conditions. The other symptom is leaf shredding/splitting that occurs because of rapidly multiplying oospores which causes the cells to break and the leaf to shred. The two symptoms represent the asexual and sexual phases of this oomycete pathogen. Downy mildew is caused by members of the *Peronosclerospora* genus including *P. sacchari*, *P. philippinensis* and *P. miscanthi*. PCR primers were designed to amplify across a deletion in the Cox1 gene of the *Peronosclerospora* in the aim of producing a species specific diagnostic test. The PCR detects three amplicon sizes from the PNG specimens: one short amplicon (~200bp) one medium amplicon (~250bp) and one large amplicon (~300bp). Herbarium specimens and specimens from other countries were included in a phylogenetic analysis that used DNA sequence and gap coding data. The three groups were maintained, however 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. We conclude that the *Saccharum* and *Miscanthus* infecting *Peronosclerospora* in PNG require further classification, and that it is likely a new species exists in PNG.

BP 27

ASSESSING YIELD LOSS CAUSED BY SMUT AND RED STRIPE IN SUGARCANE PRODUCTION FIELDS

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Keywords: *Sporosorium scitamineum, Acidovorax avenae* subsp. *avenae*, *Saccharum spp*.

A yield-loss study was established in 2013 in two sugarcane fields of cultivar L 01-299 (one plant-cane and one first-ratoon). Both fields were affected by smut caused by *Sporosorium scitamineum*. Disease incidence (percent infected stools per plot) was recorded for 90 plots (single-row, 15.24 m) in the plant-cane field and 93 plots in the first-ratoon field. The average smut incidence in the plant-cane field was 7.3% (range 0-37%) in 2013 and 5.0% (range 0-18%) in 2014. The average smut incidence in the first-ratoon field was 8.8% (range 0-21%) in 2013 and 3.3% (range 0-13%) in 2014. In 2013, a significant negative correlation was observed between yield of cane and sucrose and smut incidence in the plant-cane field. Although not significant, a similar trend was noted in the subsequent first-ratoon crop in 2014. The 2013 yield results from the first-ratoon field, although not significant, suggested a negative correlation between yield and smut incidence. A significant positive correlation between yield and smut incidence was observed on the second-ratoon crop in 2014, 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 L 01-299. Another yield-loss study was established in 2010 involving a plant-cane field and a first-ratoon field of sugarcane cultivar HoCP 00-950. Both fields were affected by red stripe caused by *Acidovorax avenae* subsp. *avenae*. Disease incidence (percent stalks with symptoms) was recorded in 113 single-row, 15.25 m plots in the plant-cane field and 84 plots in the first-ratoon field. 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.

BP 28

SUGARCANE BROWN RUST CONTROL AND ITS EFFECT ON YIELDS OF LCP85-384 DURING FOUR GROWING SEASONS IN TUCUMÁN, ARGENTINA

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Keywords: *Puccinia melanocephala*, disease severity, fungicides, disease chemical control.

Sugarcane represents the main agro-industrial activity in Tucumán province, Argentina. This crop is affected by a number of diseases, including brown rust (*Puccinia melanocephala* H. & P. Sydow), which can decrease production and yields. Brown rust has been present in Tucumán since 1988, but in recent years high severity levels of the disease have been observed in cultivars previously characterized as resistant. The use of fungicides to manage brown rust and the effect of the disease on LCP85-384 yield was evaluated in a field experiment conducted during four growing seasons (2009, 2010, 2011 and 2013). During 2009, 2011 and 2013, chemical treatments including a fungicide (pyraclostrobin and epoxiconazole), applied at 15-day intervals at six different stages of the epidemic, reduced the area under the disease progress curve (AUDPC) by 56%, 43% and 45%, respectively, in comparison with the untreated control. The maximum rust severity values observed under chemical treatments were 4.4%, 8% and 12% in 2009, 2011 and 2013, respectively. In 2010 no reduction was recorded, since environmental conditions did not favor the development of the disease altogether. The disease had no effects on sugarcane yield components during 2009, 2011 and 2013. No significant differences were detected for cane yield or sugar yield, in spite of the significant differences in brown rust severity between the untreated control and the chemical treatments. Although the use of resistant cultivars is the best option for brown rust management, fungicide application may be considered in those cases where cultivar resistance is seriously overcome by new variants of the pathogen.

NOTES

POSTER SESSION

BPP 29

REACTION OF SUGARCANE GENOTYPES TO ORANGE RUST AND TO BROWN RUST

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Keywords: *Saccharum* spp.; *Puccinia kuehnii*; *P. melanocephala*; Area under disease progress curve; Severity.

Sugarcane orange rust, caused by the fungus *Puccinia kuehnii*, and brown rust, caused by *P. melanocephala*, are diseases that cause significant damage to sugarcane. Both are controlled by planting resistant cultivars. For this reason, the Sugarcane Breeding Program of the Federal University of Sao Carlos (PMGCA/UFSCar), which integrates RIDESA, incorporated into its selection flowchart a phase to determine the reaction of the most promising clones to orange and to brown rusts, aiming to release of highly resistant cultivars. The experiments are conducted in the field under natural infection conditions. The cultivars RB835486 and SP89-1115, susceptible to brown and to orange rust, respectively, are planted to increase the inoculum pressure into the field. The experiment design is set under a randomized complete block with three replications, planted in double-row 2-m plots, spaced 1.4 m. The severity is assessed in a 15-day interval, using as reference the third expanded leaf, until the stabilization of symptoms in susceptible cultivars. At the end of severity evaluations, the area under disease progress curve and the maximum severity are determined. Data are submitted to variance analysis and cultivars are compared by Scott-Knott test at 5% significance level. Between 2012 and 2015, three experiments were performed in which 67 RB (Republic of Brazil) genotypes, recently released or at final assessment trials, were studied. Considering orange rust, 53 genotypes (19%) are resistant to the disease, 12 (18%) have intermediate reaction and two (3%) are moderately susceptible. Concerning the brown rust, 66 genotypes (99%) are resistant to the disease and one (1%) has intermediate reaction. The incorporation of this experiment in the PMGCA/UFSCar/RIDESA selection flowchart has allowed breeders to determine with security the response of the promising RB clones. Results indicate that PMGCA/UFSCar/RIDESA has successfully obtained resistant genotypes to both, orange and brown rusts.

BPP 30

DIVERSITY OF *PUCCINIA KUEHNII* AND *P. MELANOCEPHALA* CAUSING RUST DISEASES ON BRAZILIAN SUGARCANE

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Keywords: *Saccharum*, *Puccinia kuehnii*, variability, genotypic, phenotypic, DNA, races.

The sugarcane industry in Brazil suffered yield losses due to brown rust (*Puccinia melanocephala*) since 1986 and orange rust (*P. kuehnii*) as recent as 2009. The main control measure for both diseases has been cultivar resistance. Nevertheless, recent onsets of orange rust on previously resistant cultivars demonstrated lack of basic knowledge on pathogen diversity. Therefore, the present work aimed to examine genetic diversity of isolates causing brown and orange rust on Brazilian sugarcane cultivars. Total DNA from 25 isolates of *P. melanocephala* and 30 isolates of *P. kuehnii* were genotyped using 10 SRR primers and genetic diversity visualized through cluster analysis with UPGMA in the SAHN program of the NTSYS-pc package. Phenotypic data was carried out by examining virulence pattern of six isolates of *P. kuehnii* towards eight cultivars. Evaluation was made 21 days through sporulation ability and digital image of damaged area by Assess 2.0. Data of the present work showed genetic diversity of 80% between isolates of *P. kuehnii* and *P. melanocephala* as well as genetic clones among isolates of both pathogens. Phenotypic data demonstrated the existence of two different physiological races among six isolates of *P. kuehnii*, based on sporulation. Moreover, analyses of sugarcane resistance based solely on digital image could not differentiate cultivars with different sporulation ability but the same lesion area damaged.

BPP 31

QUANTIFICATION OF MONOCYCLIC PARAMETERS OF ORANGE RUST (*PUCCINIA KUEHNII*) IN SUGARCANE

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Keywords: fungus; plant disease, temperature; resistance.

Sugar cane is affected by several diseases responsible for reductions in yield. Among them, orange rust caused by *Puccinia kuehnii*, has deserved special attention by the breeding programs. In this work, the monocyclic parameters of orange rust on two different cultivars were evaluated under two conditions of temperature. Forty-day plants of cultivars SP89-1115 and RB85-5156, which are considered susceptible and moderately resistant, respectively, were inoculated with urediniospores collected from infected plants and kept in moist chamber at 22 °C for 24 hours. The plants were transferred to growth chambers with temperatures of 18 °C and 25 °C. Two identical experiments were conducted. Inoculum used in the first experiment was collected on naturally infected plants in the field while for the second experiment it was obtained through artificial inoculations. The parameters evaluated were incubation and latency periods, frequency of infection, pustules size and severity with the two temperature conditions. The use of artificially obtained inoculums proved to be more suitable for monocyclic parameters study. Temperature of 25 °C was more suitable for disease development in all parameters evaluated. Cultivar RB 855156 showed higher level of polygenic resistance than cultivar SP 891115 as revealed by longer incubation and latency periods, as well as by higher infection frequency and pustules area. Cultivar RB 855156 showed lower levels of infection frequency and pustules area only at 18 °C, revealing that its resistance is influenced by temperature.

BPP 32

EVALUATION OF PROMISING CLONES REACTIONS TO SUGARCANE SMUT (*SPORISORIUM SCITAMINEUM*) IN KHUZESTAN, IRAN

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Keywords: *Sporisorium scitamineum*, smut, screening.

The use of resistant cultivars is the best method to control sugarcane smut (*Sporisorium scitamineum*, Syd., M. Piepenbr., M. Stoll and Oberw. 2002). To study the sugarcane reaction of 48 promising clones and three commercial cultivars to smut, a screening trial was conducted during plant cane and first ratoon at the Iranian Sugarcane and By-Product Research and Training Institute. A total of 250 buds (three buds setts) from each clones were collected and dipped during 15 min. in a teliospore suspension (2 gr/l., 80% of germination). Thereafter, the setts were incubated at 28-30 ºC and 90% of relative humidity during 48 hours. The inoculated setts were planted in a field trial following a complete random block design with three replicates of 10 m. long row plot. Two months after planting infected stalks were registered and burned daily until harvest. Following a disease incidence arbitrary scale for smut screening the cultivars and clones were categorized as resistant (3.9%), moderately resistant (25.5%), moderately susceptible (47.1%), susceptible (9.8%) and highly susceptible (13.7%).

BPP 33

DISPERSAL AND HOST RANGE OF *SUGARCANE STREAK MOSAIC VIRUS* (SCSMV) IN INDONESIA

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Keywords: *Sugarcene streak mosaic virus*, dispersal, host range.

Streak mosaic disease caused by *Sugarcane streak mosaic virus* (SCSMV) is a newly disease affecting sugarcane plantations in Indonesia. Since the first report in 2005, disease incidence and virus distribution increased gradually. The presence of SCSMV can cause significant economic losses to sugarcane plantation in Indonesia. To develop disease management, dispersal mechanism and host range of the virus is required to be studied. This paper reported the recent distribution, dispersal mechanism and host range of SCSMV in Indonesia. The results of the survey to monitor the recent SCSMV distribution revealed that from time to time the distribution and occurrence of SCSMV were more widespread. The virus was observed at Jatitujuh and Subang Sugar Mills and it has not been reported before. Some leaf samples with mosaic symptoms received from West Papua were also detected positively with SCSMV. The dispersal of SCSMV in Indonesia occurred mainly due to the transmissibility of the virus through cane cuttings and transportation of infected cane cuttings from one area to other areas. The virus dispersal was also related to the wider planting of highly susceptible cultivar PS 864 in the fields. No insect has been determined as a vector of SCSMV hence dispersal of the virus through insect vector is unknown. In the field, SCSMV could survive from season to season on sugarcane crops especially on the highly susceptible cultivar planted continuously in a large area such as PS 864. The results of host range test revealed that the alternative hosts of SCSMV included sorghum, maize, several species of wild cane and their relatives namely *Saccharum officinarum, S. spontaneum, S. robustum*, *S. barberi, S. sinense* and *Miscanthus*, and also several species of weed grasses namely *Brachiaria moniliformis, Panicum repens, Paspalum conjugatum,* and *Rottboelia exaltata.*

BPP 34

EFFECT OF RATOON STUNTING DISEASE (RSD) ON SUGARCANE YIELD IN FIJI

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Keywords: Ratoon stunting, hot water treatment, cane yield, sugar yield.

Sugarcane *(Saccharum officinarum*) ratoon stunting caused by bacterium *Leifsonia xyli* subsp. *xyli* has been reported to cause huge yield losses in ratoon crops,. A study was conducted to determine the better of two hot-water treatments of sugarcane setts of cultivar Mana before sowing in the field to minimize losses from ratoon stunt. The hot-water treatments were either 2 hours at 50ºC or 3 hours at 50ºC. The differences in cane yield were recorded with all the treatments in the cane yield loss experiment but the differences were not statistically significant. It was observed that the only notable effect of the disease was on the cane yield but very little effect on the sugar per unit area and percent of pure obtainable cane sugar (% POCS). The cane yield for the plant (first) crop and subsequent ratoon crops (third year, fourth year, etc.) differed with an average reduction of 37% but the average loss caused by ratoon stunt was 29%. Out of the two hot water treatments, the best duration of hot water treatment was identified as 2 hours at 50ºC because it gave a higher average yield compared to the control (untreated) and 3 hours at 50ºC. Three hour duration seems to affect germination of sets and thus total plant population which eventually results in low yield of sugarcane and thus total % POCS.

BPP 35

DESIGN OF A HYDROTHERMAL TREATMENT STATION FOR SEEDBED OF SUGARCANE

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Keywords: Hydrothermal station, re-circulation, temperature control, automated crane, control and interface.

Mexico has reported 23 parasitic diseases in sugarcane, 6 of which are considered major problems base on yield impact, and four of them are transmitted by seedcane; Chlorotic Streak (Unknown), Ratoon Stunt (*Leifsonia xyli* subsp xyli), Leaf Scald (*Xanthomonas albilineans*) and Smut (*Sporisorium scitamineum*). One of the most recommended practices by advanced sugarcane growers to obtain healthy planting material is the hot water treatment. A design of a hot water treatment station is proposed, that has two subsystems connected to a Human Machine Interface (HMI), which is manipulated by a single operator from an automatized control panel. The hydrothermal subsystem consists of a stainless steel tub (cylindrical form) with capacity of 2500 liters, which achieves an optimum homogenization of temperature (due to the calculation of the flow recirculation) and has a temperature loss of 0.2 °C per hour (due to the thermal insulation). It has three tubs to hydrate and oxygenate the seeds prior to disinfection, which also are used to impact the seed with a thermal shock after heating. The station performs the disinfection process under a strict temperature control with precision of ± 0.1 °C; This data is the result of the modern control technique implemented making the interaction between sensors and actuators. The first heating phase starts with an industrial water heater made of stainless steel. Subsequently a system of electric resistances continues with the controlled heating, point at which the disinfection time count begins. The second subsystem is an automatic electromechanical crane, which works automatically making all the movements of the baskets of seed. The touch-screen control-interface allows you to set parameters (time and temperature) and display the status of the process.

ENTOMOLOGY ABSTRACTS



BE 1

THE ROLE OF SILICON IN PLANT DEFENCE AGAINST INSECT PESTS WITH SPECIAL REFERENCE TO SUGARCANE PESTS: CHALLENGES, OPPORTUNITIES AND FUTURE DIRECTIONS IN SUGARCANE IPM

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Keywords: Silicon, environmental stressors, plant defense, herbivores, sugarcane

Silicon is one of the most common elements in the Earth's crust. The role of silicon as a plant nutrient that ameliorates the effects of a wide range of abiotic and biotic environmental stressors has received considerable attention since the beginning of the 21st century. Silicon is taken up by plants in the form of monosilicic acid ($Si(OH)_4$) and transported from the root to the shoot where it polymerizes into biogenic opal. There is growing evidence for a role of Si in induced defense of plants attacked by fungal pathogens and in increased tolerance of abiotic factors such as water stress and heavy metals. In addition, there is clear evidence that the high levels of silica in many plants, especially sugarcane and rice, have wide ranging anti-herbivore effects on both arthropod pests and vertebrates. Silicon increases the abrasiveness of plant leaves and increases hardness of stalks and shoots, which have negative effects on pests. These effects show that silica is able to alter feeding preference of herbivores for different plant species. Silicon-based defense can also affect pest performance. Both folivores and phloem and xylem feeders have been shown to have reduced growth rates, digestive efficiency and increased mouth part wear. Also, silicon-based defense can affect tritrophic interactions by altering the secondary chemical components released by plants. There are many published references indicated that silicon can enhance resistance of sugarcane cultivars against stalk borers and plant feeding mites in both pot and field trials. These unique achievements are very important in the sugar industry because in a monoculture system like sugarcane it is mandatory to focus on non-chemical based pest control strategies. In this paper we reviewed all aspects of silicon-based defense and the role of silicon as a component of integrated pest management programs, especially in sugarcane scenario.

BE2

NOVEL TECHNIQUE TO TEST FOR VARIETAL RESISTANCE TO SUGARCANE MOTH BORERS

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Keywords: *Chilo, Scirpophaga*, sugarcane, cultivar resistance

We used a novel technique to rank cane cultivars according to susceptibility to moth borer infestation. Trials were conducted at Ramu sugar estate, Papua New Guinea in 2014. We placed one potted plant in the middle of four other potted plants of the same cultivar in a shade house facility. Five months after transplanting into pots, two moth egg batches were placed on the underside of a young leaf on the central plant to serve as a source of infestation. We tested cultivars RQ117 and Q127 against *Chilo terrenellus* (Lepidoptera: Crambidae), while Q135 and Q219 were tested against *Scirpophaga excerptalis* (Crambidae). Each test was replicated 4 times for each cultivar. All plants were destructively sampled 2 months after infestation and data collected on leaf and internode damage, dead heart symptoms, larval and pupal abundance, tunnel length and larval and pupal weight. 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. This substantiates field results where consistent ratings for varietal resistance could not be demonstrated for *C. terrenellus*, and this highlights the difficulty of selecting for varietal resistance to this species. The trial design we devised takes advantage of first instar larval behavior as they disperse and settle on adjacent plants. The technique provided a reliable method to screen cane cultivars against these borer species. This technique may be further improved by placing a second set of potted plants around the original set. This will allow early hatchlings to disperse further and settle on more plants, thus improving the ability to detect potential resistance/susceptibility pattern among cultivars.

BE 3

ELDANA SACCHARINA WALKER (LEPIDOPTERA: PYRALIDAE) POPULATIONS AND MOVEMENT-THE ROLE OF INSECT PHYSIOLOGICAL KNOWLEDGE IN PREDICTING THESE

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Keywords: Thermal tolerance, water balance, *Eldana saccharina*, distribution, host plants, sugarcane

Understanding insects' thermal tolerance and water balance provide insights into activity and survival constraints which, in turn, help develop integrated management strategies. Here, these traits were used to understand range expansions of *Eldana saccharina* into cooler southern African environments. Individuals collected from sugarcane and *Cyperus papyrus,* then reared under laboratory conditions for 1–2 generations was the first of these investigations. Chill-coma onset temperature (CTmin), critical thermal maximum (CTmax), lower lethal temperatures (LLT), and freezing temperature of Individuals from the two populations were compared. Those experiencing the lowest environmental temperature (in *C. papyrus*) did not have the lowest CTmin, even though highest CTmax was from *E. saccharina* in *C. papyrus* (the microsite with highest maximum temperatures), suggesting host plant mediates lower critical thermal limits, but not necessarily LLT or freezing temperatures. In the second study, pronounced variation in CTmin (≥ 4 °C) across *E. saccharina*'s geographic range was shown. Two notable observations in chill-coma variation were made: (1) CTmin differs significantly between geographic lines, being positively correlated with local climates; (2) a stable genetic architecture underlies CTmin trait variation. Crosses between most and least cold-tolerant lines confirmed the genetic component in trait variation. Slower developmental time in the most cold-tolerant population suggests local adaptation involves fitness costs, but confers fitness benefits in that environment. *E. saccharina* larvae were exposed to different rearing temperatures, and resulting adult physiological performance (viz. water loss rates; time to death) and water-balance related traits (viz. body size; water content) were compared. Lower developmental temperature acclimation increased water loss by 61% and reduced survival time by 26%. Initial body water content and body mass remained similar across male acclimation groups. Higher developmental temperature acclimation reduced female body mass but resulted in significantly higher (≥23%) body water content at death. The relationship between time to death and body mass was altered from negative at 25° and 30°C acclimation, to positive at 20°C acclimation. Thus, prior thermal history i.e. low temperature acclimation, relaxed (or preconditioned) substantial constraints on water economy at higher temperatures for *E. saccharina.* These studies document substantial variability in climatic stress resistance traits, which are likely to evolve readily in new environments, responding dynamically to local microclimates both within and between generations. Further work examining adaptive (and plastic) limits of these traits would be useful.

BE 4

STATUS OF THE MEXICAN RICE BORER IN THE USA

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Keywords: Mexican rice borer, *Eoreuma loftini*, Crambidae, biological control, insecticide, host plant resistance

Following the 1979 discovery of Mexican rice borer (*Eoreuma loftini* (Dyar), Lepidoptera: Crambidae) in commercial sugarcane in the lower Rio Grande Valley of Texas (USA), the insect moved northward as a pest of sugarcane, sorghum, and maize before reaching the east Texas rice growing region in 1988. This species was first detected in the neighboring state of Louisiana in 2008 where it is now recognized as a pest of sugarcane and rice. In 2012, the insect was unexpectedly discovered in Marion County, Florida, nearly 1400 km eastward from its known USA distribution. Its distribution spread to a five-county region in central Florida by April 2015, a region 190 km north of the state's large-scale commercial sugarcane and rice production area. While limited acreage of maize, several types of sorghum, and rye are produced in the infested counties, the pest has not been detected on those crops to date. The current distribution and pest status, as well as the effectiveness of using classical biological control, insecticides, and host plant resistance to reduce the economic damage caused by *E. loftini* over the last 35 years will be discussed in reference to understanding its evolving host plant distribution in Louisiana and Florida.

BE 5

A NEW PEST IN ARGENTINA SUGARCANE FIELDS: *ANCISTROSOMA ARGENTINUM*

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Keywords: *Ancistrosoma*, white grubs, sugarcane, damage, integrated pest management, entomopathogens, Scarabaeidae.

In 2008, *Ancistrosoma argentinum* Moser (Coleoptera: Scarabaeidae) was detected for the first time in sugarcane at San Lorenzo Field (Ledesma SAAI) in Jujuy Province, Argentina. This paper describes research conducted to understand and manage this pest. First it was positively identified through morphological taxonomy. The species has a two-year cycle and 3 larval stages. The L3 development period is 16-18 months and this is the most aggressive larval stage. Nocturnal adults do not damage sugarcane and are poor fliers. Females oviposit in the soil in sugarcane fields. Larvae emerge and concentrate near the plant roots. Larvae feed on the rootlets of the cane, causing stunted growth, leaf chlorosis and in severe infestations can kill the stool. Infestations are patchy. Loss varies from 70% to 100% of the expected yield. Chemical controls were conducted with different active principles (Imidacloprid, clorpirifos, thiametoxan, teflutrina), applying them at different points in time (on December trying to control larvae and in winter during the plantation) and using different application techniques, Biological control with fungus (*Metarhizium anisopliae*) and cultural practices were also conducted. To this date, the best results in terms of grub mortality were obtained by ploughing out the infested fields followed by a long fallow (more than 4 months), crop rotation with soybean, and replanting a minimum of one year after tillage.

BE 6

ENHANCING PEST MANAGEMENT STRATEGY BY THE COMPUTERIZATION OF AGRO-ECOSYSTEM INTERACTIONS

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Keywords: knowledge based system, conceptual graph, agricultural practices, food webs, biological control

Pest management strategy aims to minimize the adverse impact of pests on the crop. Basically its building requires a balance of knowledge about farming practices, crops, pests, soil, and their interactions in regard to the landscape structure. New technologies to develop ecologically based pest management require additional knowledge about functional biodiversity in a given agrosystem. In the case of the conservation biological control, knowledge about the local landscape, i.e. natural vegetation and mosaic of crops, and its management also have to be considered to ensure the survival of natural enemies. Thus, many interactions in population dynamics have to be investigated simultaneously, with the possibility of conflicting interactions. In order to identify potential conflicts and provide sound evidence, interactions affecting sugarcane health were implemented in Cogui software for modeling. Using this software, all these interactions were represented as semantic graph, and their automatic combination reveals pest management strategy for a specific location. The interactions concerned food webs regarding different communities such as Lepidoptera, Coleoptera, Hemiptera, Hymenoptera, entomopathogens etc. and the impact of agricultural practices comprising IPM strategies, soil preparation, cultivar, irrigation, fertilization, harvest etc. on the agro-ecosystem. Using this knowledge-based system can help analyses pest problems and propose IPM solutions through thorough comprehension of the pest-natural enemy interactions in a complex landscape structure.

BE 7

MANAGEMENT PROGRAM OF THE SUGARCANE LEAFHOPPER, *PERKINSIELLA SACCHARICIDA* AND THE YELLOW APHID *SIPHA FLAVA* IN ECUADOR

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Keywords: Sugarcane, sap-sucking insects, damage, losses, natural enemies.

Tropical conditions on the Ecuadorian coast on the Guayas River banks provide favorable conditions for the development of several sap-sucking insect species which can cause significant damage in sugarcane crops. The most important are leafhopper, *Perkinsiella saccharicida*, Kirkaldy (Hemiptera: Delphacidae) and yellow aphid, *Sipha flava*, Forbes (Hemiptera:Aphididae) widely referred to in sugarcane industries as YA. The former is of Australian origin and latter from the Western Hemisphere, probably North America. Both species have been reported in the country since the 1960's and have caused significant damage to the crop, in cyclic or recurrent episodes. Field studies showed that up to 36% yield loss was caused by *P. saccharicida* and 17% by *S. flava*. The research programs for both species were focused on biology and population dynamics, natural enemies, effects on cane and sugar production, economic thresholds, and selection of the optimum control methods. The economic threshold or the best time to control *P. saccharicida* is when there are a large number of medium and large nymphs present that will lead to the migration of adults. YA threshold is set at 30% or more infested leaves, during three to four week in the dry season (June to December). In both pests, it was shown that greatest economic losses in production were related to persistence of high populations of these pests, especially during plant growth critical period (3 to 5 months old). The strategy for management of both pests is based on the ability of the plant to develop resistance to pests, the preservation and increase of their natural enemies, and the rational use of insecticides. The key natural enemies for leafhopper are *Aprostocetus* sp., *Zelus* spp. chrysopids and *Metarhizium anisopliae*; and, for YA, coccinelids (especially *Scymnus* sp., *Diomus* sp. and *Cycloneda sanguinea*), sirphids and chrysopids.

BE 8

OPTIMIZING A FIXED-PRECISION SEQUENTIAL SAMPLING PLAN FOR ADULT *ACROTOMOPUS ATROPUNCTELLUS* A NEW SUGARCANE PEST ARGENTINA

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Keywords: Sequential sampling, relative net precision, Taylor's power law, Green's model.

Sugarcane weevil borer, *Acrotomopus atropunctellus* (Boheman) (Coleoptera: Curculionidae), has been detected across all sugarcane areas in the Northwest of Argentina with increasing population densities. The objectives of this study were: 1) to describe the sampling distribution pattern of *A. atropunctellus* adults in sugarcane fields, 2) to develop and validate a fixed-precision sequential sampling plan for density estimation, and 3) to find the optimum inspection time for each sampling unit. Farm data was collected in sugarcane fields located in Ranchillos (Tucumán, Argentina) from November to April from the 2011/2012 to the 2013-2014 sugarcane growing season. Thirty sampling units consisting of a one-meter row were randomly selected at one-week intervals. Weevils were counted in each sampling unit, and recorded for five increasing examination times per sampling unit (ETSU) (2, 4, 6, 8 and 10 minutes). For each ETSU, the sampling distribution pattern was assessed with Taylor's power law (TPL). The average sample number (ASN) and sampling stop lines were calculated according to Green's sequential sampling model, based on TPL estimated parameters, for fixed precision levels: C=0.1 and C=0.25. The resampling for validation of sample plans (RVSP) program was used to evaluate the performance of the different sampling plans. Parameters *a* and *b* from TPL regressions did not vary significantly among different ETSUs. All estimates of *b* coefficients were significantly > 1, which indicates an aggregated sampling distribution pattern. For each precision level, Green's sequential plans predicted very similar ASN among ETSU. This was confirmed through the validation process, with the five sampling protocols providing very similar mean sample sizes and mean precision levels. Variability of these parameters from validation results did not vary significantly among the different ETSUs. Relative net precision was the only performance parameter that varied with the ETSU, with the shortest ETSU resulting in the most efficient sampling plan. We conclude that *A. atropunctellus* has an aggregated sampling distribution, and that the 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. Our analysis of ETSU effect on the performance of sugarcane weevil sampling protocols could be applicable for monitoring other arthropods.

BE 9

DETECTION OF WHITE GRUB INFESTATIONS BY SATELLITE IMAGERY IN THE CENTRAL CANE-GROWING REGION OF QUEENSLAND, AUSTRALIA

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Keywords: Canegrubs, Remote Sensing, Object-Based Image Analysis

White grubs (Coleoptera: Scarabaeidae), known locally as canegrubs, are the most serious insect pests of sugarcane in Australia. Detection of infestations at an early stage is important for implementation of control strategies to prevent damage increasing or spreading in subsequent years. However, physical monitoring of grub populations is time-consuming and arduous, and most growers will not do it. Satellite imagery was investigated as a method for detecting infestations over large areas. An area of about 70 km^2, which included about 2000 canefields, was studied over 3 years near Mackay in the central sugarcane-growing area of Queensland. This area was selected due to frequent damage by greyback canegrub, *Dermolepida albohirtum*. High spatial resolution multispectral and panchromatic satellite images were acquired in 2012, 2013 and 2014 in May-June, corresponding with the months when symptoms of feeding by greyback canegrubs are most visible. Patches of possible canegrub damage within fields were identified through visual examination of satellite imagery, and these patches were then checked for symptoms of canegrub infestation or other disorders (for example, pig or rat damage) by ground inspection. In addition, canegrub-damaged patches were identified and mapped from ground observations independent of the satellite images, and grub numbers in some patches were quantified by counting under cane stools. During 2014, the images taken over three years were processed using geographic object-based image analysis (GEOBIA) to identify likely patches of damage based on differences in the Normalized Difference Vegetation Index (NDVI) and image texture within fields. We present the image analysis methodology and discuss the agreement between satellite and ground-based detection of greyback canegrub infestations. Errors of omission (false negatives) were less than 15% every year. However, grub-unaffected areas with other problems such as waterlogging, pig damage or weed infestations were sometimes incorrectly classified as grub-damaged.

BE 10

DISTRIBUTION OF SUGARCANE LONGHORN BEETLE IN THAILAND

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Keywords: Sugarcane insect pest, biological control, *Metarhizium anisopliae*

An exhaustive survey of the major pest, the longhorn beetle, *Dorysthenes buqueti* Guerin (Coleoptera: Cerambycidae**)** was conducted in Thailand to determine the species distribution in sugarcane fields. This pest was distributed in all commercial sugarcane regions including Central, North and Northeastern Thailand. The pest was found in sandy loam, loam, clay, silt, fine loam, coarse loam, clay loam, sand and loamy sand or gravelly clay soil textures. Meanwhile, the beetle was not recovered in clay/silty clay loam or clay/heavy clay soil textures in some Provinces i.e. Lopburi and Petchabun Province. The larvae were particularly common from 1 to 294 meters above sea level. Green muscardine entomofungus, *Metarhizium anisopliae* was collected. *M. anisopliae* isolates collected from Nakhon Pathom Province (KPS), Kanchanaburi Province (LKK and DTK) and Chon Buri province (NBC) were particularly efficient against *D. buqueti*. This mycoinsecticide will provide control for *D. buqueti* in Thailand.

BE 11

ECONOMIC IMPACT OF MOTH BORERS ON SUGAR YIELD IN THAILAND

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Keywords: Sugarcane insect pest, biological control, parasitoid, *Cotesia flavipes*, economic impact.

Sugarcane moth borers are destructive insect pests of sugarcane in Thailand, comprising the crambids, *Chilo infuscatellus* Snellen, *Chilo sacchariphagus* (Bojer), *Chilo tumidicostalis* (Hampson), *Scirpophaga excerptalis* (Walker) and the noctuid, *Sesamia inferens* (Walker). Field augmentative biological control research was conducted in two consecutive cropping seasons (2009-2011) to compare the yields and net income of 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 plots where no parasitoids were released (control plots). In treated plots, significantly ($P<0.05$) higher yields of 84.38 ±5.21 tons cane/ha in 2009/2010 and 86.47 ±7.07 tons cane/ha in 2010/2011 cropping seasons were obtained, compared to untreated plots that produced 66.4 5±7.62 tons cane/ha and 67.60 ±4.79 tons cane/ha respectively. Net income in the former treatment was 1,637.78 US$/ha in 2009/2010 and 1,340 US$/ha in 2010/2011 cropping seasons), which was significantly ($P<0.05$) higher than yield in untreated plots of 532.37 US$/ha in 2009/20110 and 322.61 US$/ha in 2010/2011.

BE 12

SUGARCANE DETERIORATION CAUSED BY *DIATRAEA SACCHARALIS* IN TUCUMÁN, ARGENTINA

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Keywords: Sugarcane, mannitol, losses, infestation, stemborer, bacteria.

The sugarcane borer, *Diatraea saccharalis* F. (Lepidoptera: Crambidae) is the main sugarcane pest in North West Argentina, especially in Tucumán Province. The tunnels produced by the larvae when they bore into the stalks provide an entrance hole for *Leuconostoc mesenteroides*, an epiphytic bacteria, which causes cane quality deterioration. These bacteria produce dextran, polysaccharides and mannitol (a polyol), causing damage throughout the production cycle. Mannitol can be used to predict sucrose losses, when the level is higher than 300 mg/kg %ºBrix. This work aimed to establish sugar losses and juice degradation caused by *L. mesenteroides* in association with *D. saccharalis* infestation. During the 2009 harvest season, trials were carried out in the Fronterita (Famaillá) mill fields, planted with 3 of the most common commercial cultivars in the area: LCP 85-384, TUC 77-42 and RA 87-3. Ten stalk samples, representing different infestation levels were analyzed: undamaged cane 0% (control) and cane with 5-10%, 11-20%, 21-30%, and >31-40% damaged internodes. Three replicates were analyzed per cultivar and damage level were included in the study at three crop cycle stages, beginning of harvest, mid-harvest, and end of harvest. Samples of cane stored for 5 days were compared with no storage or immediately after harvest Juice was extracted and mannitol was analyzed. TUCCP 77-42 had the highest sugar loss, and this value increased as the harvest season progressed. Storage losses were highest in samples of TUCCP 77-42 and lowest in LCP 85-384. Sugarcane with 0% infestation, with and without storage, showed deterioration levels below 300 mg/kg %ºBrix. TUCCP 77-42 and RA 87-3 deteriorated according to the amount of mannitol from 5% infestation and above from the beginning of the harvest season, and LCP 85-384 from 10% infestation at end of the harvest season.

BE 13

MAURITIUS: 250 YEARS OF BIOLOGICAL CONTROL IN SUGARCANE

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Keywords: Insect pests, natural enemies, weed biocontrol, sugarcane

In 1762 the Mynah bird (*Acridoteres tristis*) was introduced into Mauritius from India to control Red Locusts (*Nomadacris septemfasciata*). This was most likely the first record of a successful biological programme in the world However, in 1900 the Indian mongoose was introduced for the control of the black rat but it became a nuisance because it preys on poultry. In the early 1900's the major pest in sugarcane was the sugarcane white grub (*Phyllophaga smithi* known then as *Clemora smithi*). In 1911 it was observed for the first time on about 1200 ha of sugarcane. Extensive control programmes commenced and tiphiid and scoliid wasp species were introduced from Barbados, Madagascar, Java, Puerto Rico and South Africa. Sugarcane is the main crop in Mauritius. Biological control has been adopted for the control of the following major pests: the stem borer (*Chilo sacchariphagus*), the shoot borer (*Sesamia calamistis*), and white scale (*Aulacaspis tegalensis*). The success achieved in sugarcane motivated biocontrol programmes in several other crops. Vectors of sugarcane viral diseases e.g *Perkinsiella saccharicida* have been controlled by the introduction of natural enemies. Biological control of invasive plant weeds such as *Lantana camara*, *Opuntia* spp. and *Cordia macrostachya* were also successful. Recently the curculionid (*Athesapeuta cyperi*) was introduced to control *Cyperus* spp. Despite the development of synthetic insecticides, biological control remains the main strategy for insect pest management in Mauritius. Sugarcane pest management strategies are aimed towards conservation of natural enemies, and insecticides are not used on a large scale. With the globalization of the economy, movement of commodities and people around the world pest introductions are more common. Therefore pest management practitioners are faced with tackling these new introductions. Urbanization and climate change are other issues which could affect biological control.

BE 14

FUNGAL ENTOMOPATHOGENS: INTER-HABITAT CYCLING, GENETICS AND THEIR IMPACTS ON SUGARCANE WHITE GRUBS

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Keywords: *Beauveria brongniartii, Beauveria bassiana, Schizonycha affinis, Pegylis sommeri,* bioassays, mycoinsecticide.

Schizonycha affinis and *Pegylis* (=*Hypopholis*) *sommeri* (Coleoptera: Melolonthinae) populations have increased in sugarcane in KwaZulu-Natal. Crop losses, low insecticide efficacy, and the discovery of indigenous entomopathogenic fungal epizootics, have generated interest in developing adult and larval mycoinsecticides for these species. To identify the disease-causing fungus, 17 microsatellite PCR primers targeting 78 isolates of *Beauveria* DNA were used. Microsatellite data resolved two clusters of *Beauveria*, representing *B. bassiana* and *B. brongniartii* species groups. These groupings were supported by nuclear ribosomal Internal Transcribed Spacer (ITS) and nuclear Bloc gene regions, of which 23 *Beauveria* isolates were represented and sequenced. Further data analysis distinguished 26 haplotypes among 58 isolates of *B. brongniartii*. Low levels of genetic diversity were detected between these and isolates were closely related. Cycling of *B. brongniartii* conidia from arboreal forest to subterranean sugarcane habitats by *P. sommeri* was revealed by the analyses.

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* (Coleoptera: Tenebrionidae). Virulence of *B. brongniartii* isolates varied in both these species (50.1–95% and 39–74% respectively). Those isolates sharing haplotypes did not vary in virulence. *Schizonycha affinis* adults were more susceptible than larvae to *B. brongniartii* isolates. Median lethal concentration (LC_{50}) required to kill adult *S. affinis* was 7.65 x 10^6 conidia per millilitre. *Schizonycha affinis* second instar larvae had a median survival time of 17.5 days when exposed to *B. brongniartii* isolates at 10^8conidia/ml. However, third instars survived significantly longer (median of 21 days at 10^8conidia/ml). Third instars exposed to the highest concentration (10^9conidia/ml) of *B. brongniartii* isolate HHWG1 survived for a median time of 15 days. 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 the very desirable trait of host specificity.

BE 15

WHY DON'T INDIGENOUS PARASITOIDS OF *ELDANA SACCHARINA* WALKER ATTACK ITS LIFE STAGES IN SUGARCANE- A BREEDING OR ECOLOGICAL PROBLEM?

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Keywords: Tri-trophic interactions, sugarcane genealogy, chemical ecology, plant volatiles, frass volatiles, *Sesamia calamistis, Chilo partellus, Cotesia sesamiae, Xanthopimpla stemmator.*

Southern African sugarcane is attacked by *Eldana saccharina* (Lepidoptera: Pyralidae). Lack of parasitoid colonization/establishment has however hampered biological control success. This is in contrast to the success of parasitoids on *E. saccharina* in its indigenous wetland sedge hosts. Parasitoids use host plant odours and frass to locate hosts. Unfortunately information on attractiveness of both these odour sources from different sugarcane genotypes is limited. In Petri dish and Y tube olfactometer bioassays, *Sesamia calamistis* (Lepidoptera: Noctuidae), (parasitized in sugarcane), *Chilo partellus* (Lepidoptera: Crambidae) and their parasitoids were used to investigate this phenomenon. Responses of the parasitoids *Cotesia sesamiae* (Hymenoptera: Braconidae) and *Xanthopimpla stemmator* (Hymenoptera: Ichneumonidae) to frass from the three stemborers fed on N11, N21 and 51NG146 genotypes were studied. Number of visits, response and antennation time were recorded. Host acceptance was investigated using *S. calamistis* and *C. sesamiae*. Frass from genotypes 51NG146 and N11 produced the best responses. Further, more *S. calamistis* were stung by *C. sesamiae* from 51NG146 and N11 (95%) than from N21 (67.5%). It may thus be hypothesized that although the ancestral cultivar tested (51NG146)when fed on by the stemborers tested, emitted herbivore induced volatiles (HIV's) detected by parasitoids, these emissions of HIV's are reduced in the more modern cultivars (N11 and N21), exhibited by the lack of response by the parasitoids to stem borer feeding on these cultivars. Preliminary electrophysiological studies using linked gas chromatography- mass spectroscopy- electroantennagram detection (GC-MS-EAD) investigated responses of *C. sesamiae* to volatile organic compounds (VOCs) from sugarcane damaged by *E. saccharina*. Antennal responses suggested that host acceptance could be odour-mediated. Hexane, limonene and unidentified hydrocarbons are amongst the compounds eliciting GC-MS-EAD responses. Further studies testing artificial blends of the VOCs identified are planned.

BE 16

PATHOGENICITY OF *BEAUVERIA AND METARHIZIUM SPP.* ON *TENEBRIO MOLITOR* BEETLES AND WHITE GRUB SPECIES IN MAURITIUS AND TANZANIA

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Keywords: White grubs, sugar cane, biopesticide, *Beauveria, Metarhizium*.

A project was initiated on research and development of biopesticides for white grubs (Coleoptera: Scarabaeidae) in sugar cane in the Southern African Development Community (SADC) region. The project was funded by the EU under the ACP Sugar Research Programme. The main objectives were the detection, identification and isolation of entomopathogens from soil samples, scarab larvae and adult beetles. Weekly surveys and light trappings were carried out in sugar cane fields in areas prone to white grub infestation. All pathogens were accessioned in the South African National Collection of Fungi (SANCF) in Pretoria. Fungal isolates with a percentage germination of between 80% and 100% were normally selected and used for bioassays on *Tenebrio molitor* L. beetles (Coleoptera: Tenebrionidae) at ARC-Small Grain Institute, South Africa. Optimisation of the bioassay protocol involved the testing of different conidial concentrations and identification of a suitable diet for the beetles so as to ensure low control mortality. *Beauveria* spp., strains BbrC17 and TPC 077 and *Metarhizium* spp., strains MSIRI 134 and CADZW, showed most potential. Post-treatment observations after 7 days showed 97-100 % mortality for all four isolates while percentage mycosis ranged from 80% to100%. The *B. brongniartii* strain BbrC17 was mass-produced and formulated by Plant Health Products (Pty) Ltd. in South Africa. Its efficacy was evaluated in laboratory bioassays on *Heteronychus licas* Klug and *Alissonotum piceum* Fab. in Mauritius and on *Cochliotis melolonthoides* (Gerst.) in Tanzania. Preliminary replicated field trials were also initiated in severely infested areas. Both laboratory and field assessments revealed that BbrC17 was not virulent to the local white grub species as overall mortality and mycosis were very low. Investigations into the infective potential of the other isolates namely MSIRI 134 and CADZW on white grubs are in progress.

NOTES

POSTER SESSION

BEP 17

TOWARD A SUSTAINABLE MANAGEMENT OF THE SUGARCANE RUST MITE IN FLORIDA

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Keywords: Sugarcane rust mite, *Abacarus sacchari*, Eriophyidae, plant physiology, mitocide, host plant resistance.

The Old World pest sugarcane rust mite (*Abacarus sacchari*, ChannaBasavanna, Actenidida: Eriophyidae) was first identified feeding on advanced sugarcane selections at Canal Point, Florida, USA in November 2007. The following year it was found throughout the Florida industry, particularly on cultivar CP 89-2143. The mite was subsequently shown to reduce photosynthesis, chlorophyll content, stomatal conductance, and increase CO_2 concentration in sugarcane leaves. Results of cultivar surveys, mitocide efficacy tests, and host plant resistance will be discussed in relation to efforts to establish sustainable management of this pest mite.

BEP 18

"INTERDISCIPLINARY KNOWLEDGE PRODUCTION" IN PRACTICE: EXAMPLES FROM IMPLEMENTATION OF THE PUSH-PULL HABITAT MANAGEMENT STRATEGY AGAINST *ELDANA SACCHARINA* IN KWAZULU-NATAL, SOUTH AFRICA

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Keywords: Commercial farmers, Small-scale farmers, technology transfer, sugarcane.

"Push-pull" for controlling *Eldana saccharina* is promoted as part of an area-wide integrated pest management (AW-IPM) program in South Africa. However, successful implementation of AW-IPM relies on interdisciplinary knowledge, including entomology, agronomy and social sciences. Especially, it requires recognition of the role of local knowledge which underpins farmers' practices and decision-making. Thus, understanding farmers' perceptions of pests and pest management can improve rates of adoption of management strategies, particularly for knowledge-intensive practices such as AW-IPM. This is demonstrated in this paper. Fifty-three large-scale farmers were interviewed using a semi-structured questionnaire. Respondents recognized *E. saccharina*'s threat, and 83% had knowledge of push-pull and IPM. Ecozone delineation was more important in adoption decisions than demographic and general enterprise factors (e.g. farmer age, experience, land tenure), supporting suggestions that experiential learning activities with small groups of farmers at locally-oriented field days and model farms are best for introducing new strategies. Such platforms allow for knowledge sharing across the science-practice boundary in agricultural systems. Additionally, 35 small-scale farmers in the same area were interviewed. Data were collected through semi-structured interviews, participatory sketch mapping, matrix scoring activities and informal field-based discussions. Sugarcane, a key livelihood resource providing employment and income, generated more income than any other single agricultural enterprise. However, pest management was not considered a key constraint by these farmers, an important finding for the design of extension programs for the region. Considering the importance of sugarcane as a cash crop in farmers' livelihoods, further development of land to sugarcane will continue to reduce poverty and improve livelihoods. *Eldana saccharina* may not be a priority for all farmers in this region, as it is not a major player in the immediate decisions needed for farm management. However, they should not become complacent about it, as its range is increasing. These lessons learnt and results from this project are useful to formulate future participatory push-pull and AW-IPM dissemination activities and extension programs for sugarcane farmers in South Africa.

BEP 19

SUGAR CANE WHITE GRUBS (COLEOPTERA: SCARABAEIDAE) IN AFRICA AND INDIAN OCEAN ISLANDS: THEIR STATUS AND THE POTENTIAL FOR FUNGAL ENTOMOPATHOGENIC CONTROL

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Keywords: White grubs, biological control, entomopathogenic fungi, sugarcane.

In terms of damage and distribution, white grubs are predominant soil pests associated with sugarcane. Several pest species are recorded in Africa and the Indian Ocean islands. The most widespread species is *Heteronychus licas* Klug (Dynastinae), reported in more than 15 countries, and probably also present but unreported in other countries where sugarcane is grown on heavier clay soils. Severe damage by *H. licas* adults and larvae in plant cane fields in Mauritius may cause 100% loss, and lead to costly field replant programs. Promising indigenous pathogenic strains of *Metarhizium anisopliae* have been isolated from *H. licas* in Mauritius and Zimbabwe. In Tanzania, *Cochliothis melolonthoides* Gerstaecker (Melolonthinae) causes up to 70% loss in ratoon cane, and in Somalia, another melolonthine *Brachylepis werneri* La Croix has been recorded as a pest in sugarcane. An effective fungal entomopathogen, *Ophiocordyceps barnesii* has been isolated from both species. In southern and eastern African countries the melolonthids *Schizonycha affinis* Boheman and *Pegylis (=Hypopholis) sommeri* Burmeister are sugarcane pests, and extremely virulent strains of *Beauveria brongniartii* have been isolated from South Africa. *Hoplochelus marginalis* Fairemaire (Melolonthinae) which is exotic to, but a major pest in Reunion, is the only white grub species in the region successfully controlled with a commercial formulation of *B. brongniartii* (BETEL®). Rutelines such as *Anomala* spp. and *Adoretus* spp. occur in several countries but do not reach major pest status. Biological and ecological differences between melolonthines, rutelines and dynastines render their management difficult. However indigenous fungal entomopathogens that offer a novel control option are discussed.

BEP 20

FEEDING BY *ACROTOMOPUS ATROPUNCTELLUS* AND OVIPOSITION PREFERENCE ON SUGARCANE SHOOTS

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Keywords: weevil, larvae, leaf punctures, oviposition, sugarcane shoots.

Most species of the Curculionidae family are phytophagous in their larval and adult stages, and many species are agricultural pests. In Argentina, the curculionid pests which affect sugarcane are *Acrotomopus atropunctellus* (Curculionidae) in Jujuy, Tucumán and Salta provinces, and *Naupactus purpureoviolaceus*, *N. verecundus* and *N. cinereidorsum* in Santa Fe Province. Punctures produced by adults for oviposition and feeding cause different damage symptoms depending on the size of the sugarcane shoot. This study aimed at establishing oviposition and feeding preference of *A. atropunctellus* under greenhouse conditions. In 2012, adults were collected in commercial sugarcane fields (cultivar LCP85-384) located in Ranchillos, Tucumán, Argentina (26°59' 5" S, 65°00' 36" W) Shoots were classified as small (5-7 mm), medium (7-9 mm), and large (10-12 mm) in diameter. The experimental unit consisted of a 5 liter pot containing one shoot per diameter type, and forest soil as substrate. To determine feeding preference, each experimental unit was inoculated with one adult and the number of punctures was counted. One group contained males and the other females. For oviposition preference, the experimental units were infested with one weevil of each gender. After two weeks the shoots were dissected to count the grubs. The feeding preference results indicated that *A. atropunctellus* preferred large and medium shoots, irrespective of gender. Females produced 22% more punctures than males, probably on account of their need for energy reserves. *A. atropunctellus* females preferred laying their eggs on large and medium shoots, as indicated by the number of larvae found.

BEP 21

PRELIMINARY STUDIES ON THE ARTHROPOD BIODIVERSITY ASSOCIATED WITH SUGARCANE IN PANAMA AND THE IMPACT OF STEMBORERS

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Keywords: Stemborers, sugarcane, functional biodiversity, parasitoids, traps, pheromones

In Panama, lepidopteran stem borers *Diatraea saccharalis* (Fabricius) (Crambidae), *Telchin licus* (Durry) (Castniidae) and *Elasmopalpus lignosellus* (Zeller) (Pyralidae) are the most important pests for the sugarcane industry. The objective of this preliminary study was to start an inventory and assessment of the fauna (invertebrates and vertebrates) and flora associated with the sugarcane agrosystem and to investigate the damage and impact of stemborers. In addition, we also conduct preliminary tests with the synthetic pheromones of *D. saccharalis* and *E. lignosellus*, the main species.. The observations were conducted in 2015 during 4 months, from january to april in CALESA Sugar Company, Panama. Borer damage was assessed on a total of 2100 stalks taken from one single field. On average, infestation level was 23.5% of stalk damaged with 1.4% of internodes bored The larval parasitism rate on *D. saccharalis* was 23.53%, comprising *Cotesia flavipes* (5.88%), *Lixophaga diatraeae* (5.88%) and *Billaea claripalpis* (11.76%). The majority of the holes and tunnels from this borer species were located between internodes 13 and 20 in the middle section of the stalk. Nine species of vertebrates (birds, bats, lizards mainly) and 16 orders, 57 families and 66 species of arthropods were recorded. A list of pests and predators such as spiders, ants and other groups are being identified or confirmed. *D. saccharalis* pheromones did not attract this species in trapping experiments, despite the use of different trap designs whereas as *Elasmopalpus* synthetic pheromone attracted adults. Further tests will be conducted on a longer period.

BEP 22

INSECT-PATHOGEN INTERACTIONS IN SUGARCANE: FURTHER KEY KNOWLEDGE COMPONENTS IN DEVELOPING AN INTEGRATED PEST MANAGEMENT STRATEGY AGAINST *ELDANA SACCHARINA* WALKER

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Keywords: *Fusarium,* attraction, repellancy, chemical ecology, maize.

When *Eldana saccharina* bores into maize and sugarcane, tissue surrounding borings becomes reddish, often affecting a whole internode. Workers in West Africa, and more recently in South Africa, cultured numerous *Fusarium* species isolates from the red tissue surrounding *E. saccharina* borings, and from undamaged stalks, the *Fusarium* entering through rind cracks. These *Fusarium* species in plants can make the plants either have repellent/insecticidal properties to insects, or increase the attractiveness of the host plant to insects. Certain *Fusarium* species (e.g. *F. verticillioides*) produce volatiles known to be attractive to insects. These volatiles are thought to increase the likelihood of fungi being vectored by insects to their hosts. Increased damage by *E. saccharina* in maize that was infected with *F. verticillioides* has been reported. Maize infected with *F. verticillioides* was more attractive to *E. saccharina* moths (four fold increase in numbers of eggs laid) and more conducive to the survival and development of *E. saccharina* larvae. Laboratory assays have shown that *Fusarium* spp. isolated from sugarcane affects *E. saccharina* larvae positively or negatively, depending on the species, when incorporated into a diet mix, and that neonate larvae can be attracted to and repelled from tissue infected with different *Fusarium* species. These interactions are being investigated in novel ways in the development of an integrated pest management strategy against *E. saccharina*. Hot water treatment of seedcane followed by a fungicide dip would eliminate *Fusarium* spp. attractive to *E. saccharina* (e.g. *F. pseudonygamai*). A longer term strategy includes breeding for varietal resistance to these *Fusarium* spp., and/or breeding toxin-resistant mutagenic lines of sugarcane. Alternatively, facilitation of endophyte colonization by antagonistic *Fusarium* spp. would protect sugarcane from *E. saccharina* damage (e.g. *F. sacchari*). Furthermore, volatile differences between repellent and attractive *Fusarium* isolates can be used for the development field lures. It is unfortunate that these holistic and natural plant/pathogen/pest interactions have never been fully researched, as they offer sustainable and resilient control options for IPM in particular.

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GRASSHOPPERS AND GRASSHOPPERS- IS IT IMPORTANT TO BE A "SPLITTER"? IPM LESSONS LEARNT FROM SUGARCANE IN SOUTH AFRICA

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Historically, the orthopteran complex attacking sugarcane in Empangeni, South Africa were commonly known as "grasshoppers", and control measures applied were just as general, and hence of variable efficacy. A key to identify hoppers and adults of this orthopteran complex is presented, as is a summary of their life history traits. These basic data are important knowledge blocks on which to base sustainable, environmentally friendly Integrated Pest Management (IPM) plans for this species complex.

Damage was closely associated with two species, *Nomadacris septemfasciata* (a locust) and *Petamella prosternalis* (a grasshopper). *Ornithacris cyanea* and two other species occurred, but at lower abundance levels. All five species are univoltine, but two different life cycle strategies were discovered, a winter egg diapause (three species) and a winter adult reproductive diapause (two species). Relative abundance of the major species varied according to location: *N. septemfasciata* abundant in the south of the study area, and *P. prosternalis* in the north. Relative abundances of life stages over the sampling period showed adult *N. septemfasciata* to be present throughout winter, mating and ovipositing when spring rains commence in September/October. In contrast, *P. prosternalis* adults mated and oviposited in autumn (April/May), dying before winter. Eggs of *P. prosternalis* do diapause throughout winter. Eggs of all species hatched in late spring (November) as hoppers, developing into adults through summer. *Nomadacris septemfasciata* was most abundant during winter, while *P. prosternalis* dominated in summer. Population surveys revealed large differences in species composition between sugarcane farms and adjacent grasslands. *Nomadacris septemfasciata* and *P. prosternalis* showed a significant preference for sugarcane while *Cyrtacanthacris aeruginosa, Zonocerus elegans* and *Orthocta* sp. preferred grasslands.

Because of the very different life histories and population dynamics of the dominant species in this complex, it is clear that a common single control tactic could exacerbate the problem rather that minimise it.