Industry update

April 2015

Sugar Research Australia

YCS in Queensland in the 2015 season

Yellow Canopy Syndrome (YCS) is a critical issue for our industry and remains an extremely high priority for the SRA Board and researchers. YCS has now been confirmed in Tableland, Innisfail and Sarina and in major sugarcane growing areas north of and including Plane Creek in Queensland.

YCS forums

SRA hosted YCS information sessions in Innisfail on 14 April and Plane Creek on 20 April to provide growers unfamiliar to YCS with an overview of the broader program and details about three key research projects.

A number of other SRA events will be taking place in May and will include an update on the latest YCS information. Full event details are available at **www.sugarresearch.com.au**.

Herbert Walk and Talk Day
Ingham
Thursday 23rd April 2015

Grower Research Update Day
Tully
Thursday 14th May 2015

Grower Research Update Day
Gordonvale
Friday 15th May 2015

Mackay Field Day
Mackay
Thursday 28th May 2015

Three research projects funded by SRA and the Queensland Department of Agriculture and Fisheries aim to investigate different aspects of YCS and collectively they are expected to provide complementary information and results that build our understanding of the YCS condition and the development of management strategies.

Research project 1

Solving the Sugarcane Yellow Canopy Syndrome

Project leader:
Davey Olsen

Lead research organisation: Sugar Research Australia

Collaborations: Burdekin Productivity Services Limited and Herbert Cane Productivity Services Limited on district surveys and mill data comparisons.

Project dates: 2014–2017

Project overview: This project builds on the findings of the first year of research and will focus on a number of promising lines of enquiry. A wide range of research trials are being conducted to determine whether YCS is caused by a living factor such as an unknown disease or pest, or a non-living factor such as high temperatures or water stress. The project is also looking at the role stress plays in triggering or increasing the symptoms of YCS and will seek to develop diagnostic tools that can accurately confirm the presence of YCS in an affected plant.

Current activities: The project is on track and progressing well towards meeting its objectives. The start of a new year has once again brought with it the onset of YCS symptoms in many districts. Across the industry YCS is expanding in its distribution. Areas of Plane Creek, Atherton Tablelands, South Johnstone and Proserpine are now affected, while some new areas of Mackay and Herbert are affected for the first time. Meanwhile, many severely affected crops last year are ratooning well and are now relatively unaffected. Project investigators have been busy collecting samples over this milestone period and are now at work testing their hypotheses.

Molecular pathology work is focused on establishing if YCS is caused by a virus. Viral preps and light microscopy are being used to search for unique YCS proteins and viral inclusion bodies respectively, while generic primers are used to detect the presence of Luteoviruses.

To date no Australian YCS sample has tested positive with the generic Luteovirus primers and no viral inclusion bodies have been detected. Unique proteins have been detected in some YCS affected plant tissues and those samples will be selected for further examination by electron microscopy.

Physiology work has investigated if an external abiotic stress factor is triggering YCS symptoms in developing leaves and whether the age of the plant has any bearing on symptom expression. Preliminary results suggest a synchronized occurrence of YCS symptoms (event) in different age treatments. However, there is no evidence that the symptomatic leaves or nodes attached to those leaves had any set back in biomass accumulation. Trials have now been designed to investigate programmed cell death (PCD) as a causal agent, and will commence in late April 2015.

RGB colour discrimination work is underway to evaluate the use of colour as an early onset diagnostic tool. The relationship between leaf colour in green, YCS and dead leaves has been investigated and five different indices were developed for evaluation of leaf colours based on visible RGB spectra. Early results show promise though much remains to be done.

Investigations into the nutrient distribution and accumulation in leaf samples have suggested that those processes may differ in YCS symptomatic plants when compared with healthy plants. Further field sampling is underway, including soil, stalk, sheath and leaf samples with a focus on understanding nutrient mobilization within the plant.

A trial containing water stress and confidor treatments showed that ratings for YCS in the mid canopy were higher in the water stressed than the irrigated treatment. This may indicate that water stress influences YCS severity and whether it occurs throughout the crop canopy or just in the lowest leaves. YCS ratings were lower following confidor application, but this difference was small in comparison to the water stress treatment.

A suitable protocol for dye uptake studies in sugarcane has now been developed. This method has identified differences in dye uptake between healthy and YCS affected stalks of Q240$^{(l)}$ indicating there is a breakdown of membrane integrity, resulting in the dye diffusing into living cells. Dye uptake was also significantly less in KQ228$^{(l)}$ stalks which had been subjected to water stress in pots and developed YCS-like symptoms. The use of a starch test as a YCS diagnostic tool has been explored and, although effective, takes 48 hours to complete. Other diagnostic tools may prove more rapid.

Transmission electron microscopy work is now underway to assess YCS and healthy plant cells. Meanwhile, work is underway to test the YCS status of tissue culture material with the goal of evaluating its suitability for use as control material in experimental trials.

Research project 2

What biological factors cause or drive the development of YCS

Project leader:
Dr Frikkie Botha

Lead research organisation: Sugar Research Australia

Collaborations: World-renowned experts from institutes in Australia, Canada, Germany, the United States of America and South Africa on the collection of data and the complex analysis of results.

Project dates: 2014–2015

Project overview: Through a range of biochemical and physiological approaches this project seeks to understand how YCS affects the internal behaviour of the sugarcane plant. An understanding of what is happening inside the plant may shed some new light on the biological factors that cause or drive the development of YCS.

Current activities: This project has now established that the expression of YCS is associated with an increase in soluble sugars, especially sucrose, in the leaves. In addition to the high levels of sugars in the leaves there is a significant suppression of leaf photosynthesis, reduced stomatal conductance, increased variable fluorescence and changes in certain hormones such as abscisic acid, gibberellins and cytokinins.

This disturbance in leaf metabolism is evident throughout the canopy even in the absence of visual yellowing. It is a common comment from growers and productivity services staff that YCS is associated with a slowdown in growth and sometimes the crop does not respond at all to rainfall and other favourable growth conditions.

This project has now identified more than 200 metabolites but this is out of a total of more than 1500. The most striking differences relate to changes in sugars. However, there are additional changes that could be very important.

Firstly, there are significant levels of mannitol, kestose and lactose in some samples prepared from YCS expressing tissues. These are indicative of microorganisms (Leuconostoc) that normally associate with injured tissue, especially where there are significant available carbohydrates.

Secondly, there are significant increases in several stress related metabolite caffeoyl/chlorogenic type compounds which are indicative of wounding and activation of plant defence systems.

It remains unclear whether these are related to necrotropic organisms associated with decaying plant tissue. The initial transcriptome sequencing results indicate that the there is a wide impact on primary, secondary and regulatory metabolism.

Research project 3

A novel polyphasic framework to resolve Yellow Canopy Syndrome Paradox

Project leader:
Professor Brajesh Singh

Lead research organisation: University of Western Sydney

Collaborations: International research experts from institutes in Australia, China and the United States of America are collecting and analysing the complex dataset generated from metatranscriptomics and metagenomics and correlating those with YCS development, soil health and plant responses.

Project dates: 2014–2016

Project overview: The project will apply a comprehensive 'microbiome' based approach combining novel next-generation sequencing (Illumina) and conventional cultural techniques to provide broader view of the complexity of organisms present in YCS affected sugarcane and determine the involvement of biological agent(s) in YCS development. In addition, this project will generate key knowledge on the impact of YCS on soil health and host response which will help in understanding YCS facilitation process. This knowledge may lead to the identification of soil health management strategies that growers can put into place to manage YCS.

Current activities: The project is on track with the majority of milestones achieved successfully and on time. In November 2014, a large number of tissue and soil samples were collected near Ingham and Ayr. These samples will provide a much more valuable dataset compared to the initial samples that have been analysed so far since, in contrast to previous sampling campaigns, adequate asymptomatic and YCS-symptomatic plants were sampled in close proximity.

Thus far, it cannot be confirmed or ruled out that there is an involvement of biotic interactions and soil nutritional health in the development of YCS, mainly due to a lack of adequate asymptomatic vs. symptomatic samples to compare. However, processing of the approximately 350 sugarcane tissue samples and 350 soil samples that were collected in November 2014 is well on track and valuable data will be generated over the next few months.

Preliminary results showed interesting differences in bacterial and fungal assemblages of leaves, stalks and roots of asymptomatic vs. symptomatic plants, as well as in the soil nutrient status (C, N) and soil microbial enzyme activity between symptomatic and asymptomatic cane fields. However, these results require validation and further detailed investigation. Pathogenesis- and stress-related genes were found upregulated in YCS-symptomatic leaves and symptomatic leaves contained more salicylic acid, demonstrating the potential use of this compound as a biomarker for YCS detection.

Researcher profile

Co-investigator:
Dr Kelly Hamonts

Research Fellow,
Hawkesbury Institute
for the Environment,
University of
Western Sydney (UWS)

Project overview

UWS Research Fellow, Dr Kelly Hamonts works within the Soil Biology and Genomics theme at the Hawkesbury Institute of the Environment. In late 2014, Dr Hamonts joined Prof Brajesh Singh's team to investigate 'A novel polyphasic framework to resolve Yellow Canopy Syndrome (YCS) paradox'.

This project will attempt to identify all living organisms in YCS affected sugarcane plants to investigate the potential involvement of a biological agent in YCS development. In addition, the project will improve our understanding of the potential impact of YCS on soil health and how YCS is expressed in the sugarcane plant.

Dr Hamonts' role is to apply state-of-art next generation sequencing technologies to investigate the role of microbes in YCS development and management, and to determine any links with soil nutritional health.

Background

Dr Hamonts obtained a PhD in Bioscience Engineering from the University of Leuven, Belgium. She conducted her PhD research at the Flemish Institute for Technological Research, where she studied bioremediation of Chlorinated Aliphatic Hydrocarbons in river sediments to evaluate if such sediments can act as biobarriers for CAH-polluted groundwater.

In 2009, she joined the Bio-Protection Research Centre at Lincoln University, New Zealand, where her research focused on dynamics of key nitrogen cycling bacteria in natural and agricultural soils.

In 2012, she started a postdoctoral fellowship at CSIRO Plant Industry in Canberra, where she was involved in the Biomes of Australian Soil Environments (BASE) project that will provide the first comprehensive continent-wide inventory of soil bacterial, archaeal and eukaryotic diversity. Within the BASE project, she developed skills in metagenomics and functional assays that she will now apply to help solve the YCS puzzle.

Sugarcane researchers and technologists gather to hear update on YCS

YSC is a condition of unknown cause affecting sugarcane crops in Queensland. This was the message YCS project leader Davey Olsen highlighted during his presentation at the Australian Society of Sugarcane Technologists (ASSCT) conference in Bundaberg in April 2015.

Since YCS was first recognised in early 2012 near Cairns, it has continued to be observed in cane crops from Plane Creek to far north Queensland.

Research conducted by SRA Burdekin, Tully, Meringa, Herbert Cane Productivity Services Limited in Ingham, and Burdekin Productivity Services in Ayr has looked into the possible causes and triggers for YCS developing, in both glasshouse and field conditions.

Surveys conducted in 2014 suggest that YCS is affecting a large number of varieties. No single variety of cane has immunity to YCS, however, some varieties appear more symptomatic than others.

In the May 2014 survey, less than two per cent of all Q208$^{\Phi}$ crops were rated as severely affected, while at the same time more than 28 per cent of Q200$^{\Phi}$ were severely affected. 'It's yet to be understood whether this indicates that Q208$^{\Phi}$ is less affected by the syndrome. For example, it's possible that affected leaves are shed faster in Q208$^{\Phi}$, potentially giving the impression that a smaller percentage of the canopy is affected,' Davey said. KQ228$^{\Phi}$ also appeared to be affected to a greater degree than some of the other canes, both in the Herbert and Burdekin districts.

Conclusions drawn from these surveys include: all varieties appear to be affected by YCS to some degree and there appears to be no consistent association with soil type, crop class or farming system.

The ASSCT paper *Yellow Canopy Syndrome (YCS): A condition of unknown cause affecting sugarcane crops in Queensland* was prepared by David Olsen, Robert Magarey, Nader Sallam, Katherine Sventek, David Calcino (SRA), Lawrence DiBella (HCPSL), Michael Sefton (HCPSL), Rob Milla (BPS) and can be viewed from www.assct.com.au

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