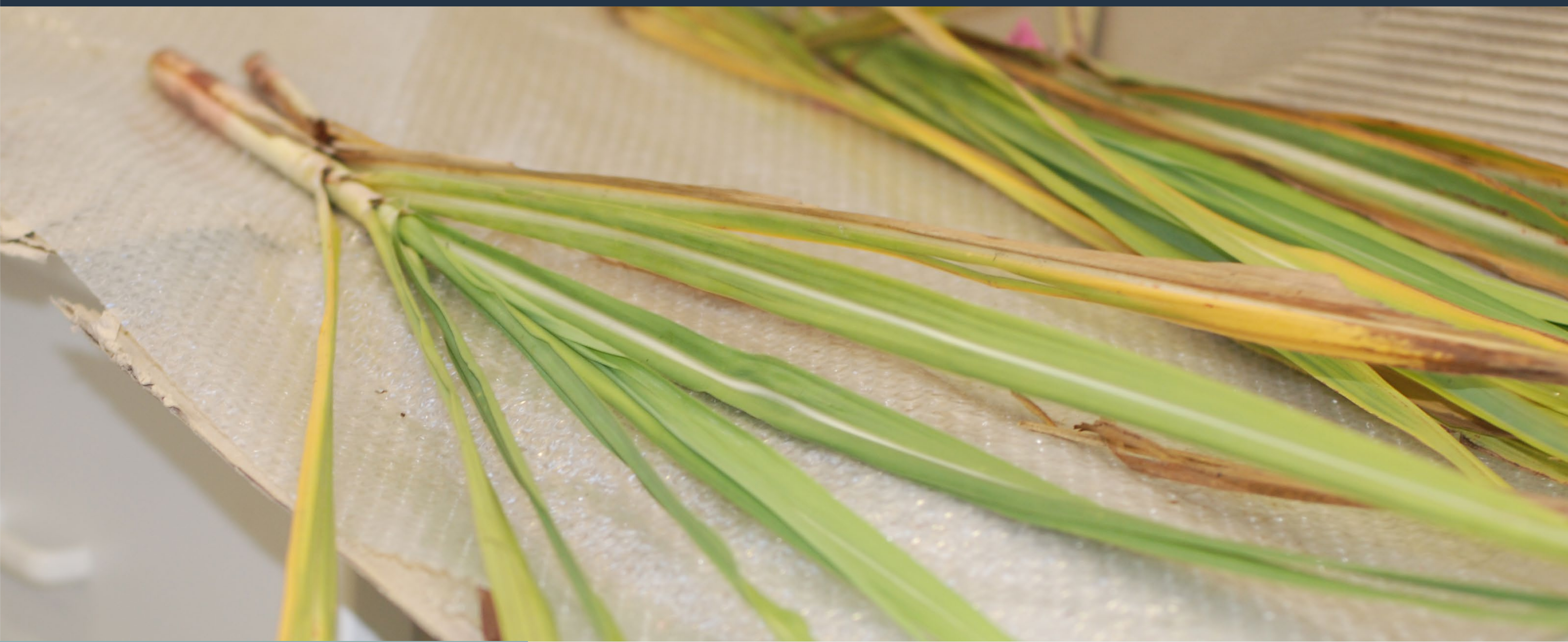
YELLOW CANOPY SYNDROME (YCS)

FINAL INDUSTRY UPDATE

by Gerard Scalia, April 2021



The YCS integrated research program conducted by SRA has now concluded. Key findings from the research are as follows.

YCS SYMPTOMS, IDENTIFICATION, CROP AGE AND SEASON

YCS is a condition of the mid-canopy (leaf +3 to +6), affects all varieties and has been confirmed as far south as Maryborough. It presents as a golden-yellow colour of the leaf blade and usually expresses after good rain following a dry or high stress period. YCS can occur in both rainfed and irrigated crops. YCS is a form of induced leaf aging (senescence) and is therefore best detected early in development to reduce misdiagnosis.

Starch iodine staining of the midrib prior to 8AM, together with key visual YCS characteristics (canopy position and colour) is a quick method of diagnosis in the field. A YCS identification test kit was developed by SRA to assist industry service providers.

YCS development and expression occurs during the peak growing period of December to March with highest severity typically noted in mid-February. This coincides with the time of accelerated growth rate due to high light intensity and temperature and a longer day length. Symptoms exhibit in the mid-canopy of crops of different ages at the same time and severity is strongly correlated with growth rate. Hence, younger and more actively growing crops typically display higher levels of YCS severity than more mature crops.

Crops do recover from a YCS event with yellowing usually subsiding from April and no longer visible by May.

PATHOGENS

Molecular screening for the presence of pathogenic organisms (phytoplasmas, bacteria, viruses, fungi and protozoa) in soil, plant tissue and sap was unable to consistently identify the presence of such agents prior to, and during, the development and expression of YCS. Samples were collected from fields, glasshouses and quarantine facilities, representing the main commercial varieties grown widely throughout Queensland.

Transmission studies using leaf tissue, juice and setts from YCS affected cane show that YCS is not caused by the transfer of an agent through these sources.

Evidently, no biotic agent is consistently present during YCS development and expression. This suggests the primary cause of high sucrose accumulation in the source leaves of the mid-canopy is not due to a pathogen disrupting sugar transport. YCS is not a disease.

YCS SYMPTOM PROGRESSION

ASYMPTOMATIC

EARLY STAGE

MID STAGE

ADVANCED STAGE

INSECTS AND MITES

Under experimental field conditions, a high concentration of a broad-spectrum insecticide promoted an increase in internode growth and effectively suppressed YCS expression by preventing the accumulation of high levels of sucrose in the leaf. As pathology studies have been unable to consistently identify any potential insect-vectored phloem blocking pathogen, it can be concluded that insects are impacting growth directly.

While insect involvement in YCS development has been confirmed in trials, the direct impact of a specific insect (or mite) in YCS development has not yet been determined. Therefore, it is likely the broad-scale removal of insect and mites reduces stress on the crop, redirecting resources from defence to stalk growth.

However, as environmental triggers influence the abundance of insect and mite species at any one time, this type of biotic stress impact on growth rate will vary within and between seasons. Therefore, the consistent use of a non-specific broad-spectrum insecticide or miticide is not a sustainable or viable option to manage YCS.

The outcome of 1ha strip trials conducted under commercial conditions in three districts in 2019–2020 showed the efficacy of a broad-spectrum insecticide to be inconclusive.

NUTRIENTS AND HEAVY METALS

Nutrient testing of soil and plant tissue confirmed YCS is not caused by nutrient deficiencies, heavy metal toxicities, or compromised nutrient mobilisation within the plant. However, elevated levels of silicon and reduced magnesium content were detected in all YCS samples across all leaves. Increased silicon uptake is typical of plants under stress. Once accumulated, silicon is no longer mobile within the plant. However, magnesium levels returned to normal after recovery, implying the previously recorded reduction was due to mobilisation of resources out of a leaf that was prematurely aging. Intensive field trial monitoring of leaf numbers shows induced senescence causes YCS stalks to always have two fewer attached leaves than green counterparts. The addition of magnesium to either the soil or as a foliar spray had no impact on YCS incidence or severity.

CROP STRESS

Crop age and growth regulator trials together with physiological studies identified growth rate to be the key driver of YCS. Research showed that YCS-like symptoms can be induced or mitigated by manipulation of stalk/internode growth (sink strength). Either abiotic or biotic stress can cause growth rate impediment and sink limitation, leading to the development of YCS. Therefore, any stress factor that impacts upon plant resources that would otherwise be used for growth is the cause of YCS.

Environmental stress response expressed through gene expression, products of metabolism and protein levels is consistently represented across all samples sets.

Stress shield chemicals induce a temporary stay-green effect and offer no long-term protection against the development and expression of YCS.

PLANT PHYSIOLOGY

YCS is a physiological disorder in response to reduced export of sugar from the source leaf (supply) to the stalk and roots (demand). In YCS this disruption may be caused by a limitation to internode size or a possible partial physical restriction in the sucrose transport system. An imbalance between supply and demand will cause sugars and glucans (soluble and starch) to accumulate in the leaf and this is exacerbated when sucrose production is highest during the peak photosynthesis and growth period of November to March.

Several physiological changes such as decreased photosynthetic rate and internal leaf CO_2 (Ci), reduced stomatal conductance, uncoupling of the photosynthetic electron transport chain, changes in carbon partitioning, reduced translocation in vascular bundles and disruption to cell membrane integrity already occur in the leaf tissue before visible yellowing. Reduced translocation of assimilates out of the leaf results in sucrose accumulation and downregulation of the photosynthetic genes. Accumulation of sucrose above an upper tolerance threshold leads to under-utilisation of incoming solar radiation, major disruption to the photosynthetic machinery, photooxidation, destruction of chloroplasts (contain green pigment) and leaf yellowing.

Gene expression data and protein levels support a general impact on leaf metabolism which is consistent with changes to source leaf metabolism. Therefore, leaf yellowing is a response to, and not the cause of impeded growth rate. As symptoms progress the leaf undergoes premature aging in response to the metabolic disruptions caused by growth disruption.

SOIL BIOLOGY AND ROOT HEALTH

Soil treatment studies of soil biology show that YCS is not caused by a soil borne agent. Root examinations also show YCS does not cause poor root health or changes to root system structure. However, it is evident from pot trials that restricted root growth increased the prevalence and severity of YCS. As the root system is a major carbon sink, any limitations on root growth should therefore be removed or managed to reduce the risk of YCS development. *(It should be noted that YCS affected crops are primarily influenced by a limitation to internode growth in the zone below the symptomatic source leaf of the mid-canopy – the proximity of this sink limitation causes a more immediate source leaf response).*

VARIETY ASSESSMENT

Comprehensive sampling and leaf sugar content analysis across all commercial varieties showed similar upper tolerance levels of sucrose accumulation. Assessment trial studies attributed variations in YCS expression to differences in canopy cover and shading of the mid-canopy. However, variation is also influenced by environmental and climatic conditions which heavily influenced water availability, sink strength (demand), photosynthetic rate and radiation use efficiency (supply).

The collective data does not support a genetic predisposition for YCS in commercial varieties throughout the regions.

YCS DISTRIBUTION AND INCIDENCE

YCS has been confirmed from the North Queensland Wet Tropics to Maryborough in the South East. However, the incidence of YCS within a region, and between regions and districts, will vary seasonally and from year-to-year due to the episodic nature of YCS. Robust data of prevalence and distribution is unlikely to be obtained without a unique diagnostic test to distinguish YCS from the many other forms of sugarcane leaf yellowing. Such a diagnostic is likely unachievable given that YCS is a physiological disorder linked to more than one growth-limiting causal agent.

YCS symptoms in the field.

CANE YIELD AND CCS

Irrespective of the field trial investigation or analytical method employed, biomass studies showed no correlation between YCS and yield (TCH and TSH) or CCS.

It is evident from the collective data that YCS is driven by reduced growth. Therefore, yield loss precedes YCS development and expression. It is this period of impeded growth that influences the magnitude of any yield (TCH) penalty. Thus, it is the intensity, duration and scale of the growth stressor, be it biotic or abiotic, that is the cause of crop yield loss and not YCS per se. Photosynthetic data suggests an approximate 2% yield loss directly attributed to YCS yellowing.

MANAGING YCS

Preventing the slowdown of growth by reducing stress (abiotic and biotic) on the crop prior to and during the peak growing season will lower the risk of YCS development and expression and is therefore key to managing YCS. Site specific crop assessment to identify growth limiting factors (above and below ground) sits at the centre of any YCS management program. Therefore, whichever farming practice removes or reduces the most dominant stressor/s impacting crop growth will be the best management option to prevent or mitigate YCS development.

YCS AND CLIMATE

The emergence of YCS in Queensland during the summer of 2012/2013 is aligned with a significant and consistent increase to mean temperature as identified by the Australian Bureau of Meteorology. This change has endured for almost a decade and has seen an increase of approximately 0.5°C during this period, contributing to increased incidence of severe weather events, rainfall variability and stress on crops throughout Australia. This increased environmental stress in addition to other stressors (abiotic and biotic) linked to a changing climate may be associated with impacts on crop growth and the physiological response exhibiting as YCS. It is not possible to rule out the appearance of some other unknown factor around 2012/2013 that has induced this physiological response.

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*(**Top**) Stress induced yellowing part of the YCS exploratory work that was conducted at the SRA Burdekin Station.*

*(**Bottom**) Dr Frikkie Botha and Davey Olsen (both former SRA staff) discussing YCS diagnosis in the field in the Burdekin.*

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