The historical emergence of Pests and Diseases in the South African Sugar Industry

History has told us that new crop pests and diseases will always emerge. Around the world sugarcane is challenged by more than 1500 insects and 80 diseases. Fortunately most of these are geographically restricted, the majority in South East Asia where sugarcane originates. Nevertheless, recent history has seen the arrival of sugarcane thrips from the eastern hemisphere in 2005, most likely via Mauritius, Reunion and Madagascar. Likewise, the yellow sugarcane aphid from the western hemisphere arrived in South Africa in 2013, having been recorded in Morocco in 2006. Both of these invaders probably arrived in mainland Africa as components of the aerial 'plankton'.

FROM LEFT:
Tawny rust on sugarcane.
Sugarcane infected with smut
Thrips in the leaf spindle of sugarcane

Examples of new arrivals can also be seen from the earliest days of the South African industry. Smut was first recorded in 1877 and could have arrived either in systemically infected imported plants, or as air-borne spores. Mosaic virus seems to have been imported in Argentinian sugarcane varieties through a rudimentary quarantine in 1915. More recently, yellow leaf virus has also escaped quarantine procedures around the globe. At the time of its' worldwide spread, suspected to be in the 1980's, molecular diagnostic tests for yellow leaf virus were not available, allowing symptomless infected material to be exchanged. To greatly reduce the risk of importing unknown viruses in future, a meristem tissue culture laboratory was added to the quarantine facility at SASRI in 2004.

THE EMERGENCE OF ELDANA

New pests and diseases can also emerge locally. Although recorded in sugarcane in Sierra Leone in 1865, it was not until 1939 that a severe infestation of eldana was found during harvesting of two year old sugarcane on the Umfolozi Flats. A more general survey suggested that the infestation was limited to this region. At first it was thought that the insect had immigrated, or been brought in with chewing-cane from Mozambique, but specimens of the moth were caught as far south as Mount Edgecombe (without larval infestations in sugarcane). It was concluded that

the insect was indigenous and widespread, in some other host plant habitat, later found to be wetland sedges.

The outbreak lasted some 10-13 years. It is not clear when and why the infestation dissipated, but it was still present at low incidence in 1950, and probably disappeared about 1953. The policy of leaving no stand-over sugarcane and a gradual change of variety to resistant variety Co281 probably hastened its population decline.

Following the reappearance of eldana in susceptible NCo376 in 1970, the pest has fully adapted to sugarcane as a host plant and has spread throughout the sugar industry. Most notably, eldana has evolved to be able to tolerate colder temperatures allowing range expansion at higher altitudes.

ADAPTATION OF DISEASES

Diseases can also appear due to evolutionary adaptation to new host plants. In 2008 tawny rust was detected on sugarcane in Swaziland and also in South Africa in 2009. This rust is unknown anywhere else in the world and is suspected to be indigenous on some other grass species. Support for this theory was obtained when tawny rust was identified by molecular DNA analysis on an unidentified grass in the Drakensberg.

THE THREAT OF NEW BORERS

Given that eldana underwent a "host-plant switch" from wetland sedges to sugarcane, it is possible that the same could happen with other borer species. Indigenous *Busseola fusca* and the South East Asian invader *Chilo partellus*, both well-known maize stem borers in many parts of Africa, have become significant pests of sugarcane in Ethiopia. Locally, these borers were reported in 2015 to be present in Pondoland sugarcane in significant numbers. *Busseola fusca* and *Chilo partellus* therefore pose internal biosecurity threats to commercial sugarcane production in South Africa.

The presence on the African mainland of the sugarcane stem-borer *Chilo sacchariphagus*, was detected in 1999. Like sugarcane thrips, this insect was known to already be present in Mauritius, Reunion and Madagascar and almost certainly arrived in Mozambique with human assistance. On the other hand orange rust, also of South East Asian origin, most likely arrived in Africa as part of the aerial 'plankton'. Orange rust is present in West Africa and the Democratic Republic of the Congo. *Chilo sacchariphagus* and orange rust therefore pose external biosecurity threats to the South African sugar industry.

THE CYCLICAL NATURE OF PEST AND DISEASE OUTBREAKS

Throughout the past 100 years, sugarcane production in South Africa can be seen to cycle through 'boom and bust' periods which can be linked to pest and disease outbreaks or build-up, followed by the expansion of more productive varieties emanating from the plant breeding programme. Since sugarcane can be regarded as a perennial that is harvested periodically, systemic diseases, which include smut, mosaic and RSD, persist and build up from crop to crop with ratooning. Once a disease does appear, the widespread occurrence of the crop, often of one dominant variety, favours epidemic development.

Drought is also a major driver of 'boom and bust', in that it increases the incidence and impact of pests and diseases, especially eldana, smut, mosaic and RSD. Periods of drought can be seen to be followed by periods when record crops are recorded. This is partly due to an increased replant rate following drought, and therefore a reduced overall systemic disease load, and greater adoption of more productive new varieties.

Immunity to pests and diseases in sugarcane is not the norm. Instead, 'resistant' varieties limit the rate of pest and disease build-up. This is known as partial resistance which may not provide sufficient control in some instances, for example during drought. Fortunately it has been found that combining partial resistance with other control measures into integrated control programmes is particularly effective.

"ADVANCES IN MANAGING PESTS AND DISEASES DEPENDS ON OUR ABILITY TO PREDICT FUTURE OUTBREAKS"

Agricultural scientists now recognise the necessity of maintaining an arsenal of control tools in anticipation of new or resurgent pests and diseases. That arsenal contains some potentially powerful weapons, among them novel approaches offered by biotechnology, biological control methods such as Sterile Insect Technology and the promise of new developments in pesticide chemistry. But, with or without new weapons, advances in managing pests and diseases depends on our ability to predict future outbreaks.

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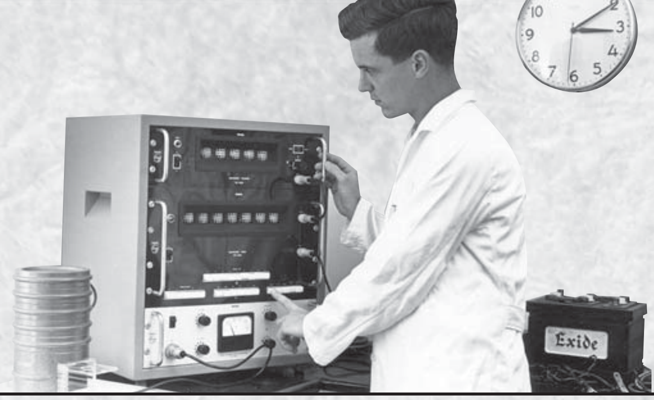
Pests and Diseases

IN THE SOUTH AFRICAN SUGAR INDUSTRY



1800 - 2016
by Dr Stuart Rutherford

A timeline of Pests and Diseases through the ages.

The 1800's

1848: Edmund Morewood plants the first commercial sugarcane on the KwaZulu-Natal North Coast

1877: First report of smut (in variety China cane; replaced by Uba and others)

1896: Locusts destroy 40% of sugarcane crop

The 1910's

1914: First quarantine/ experimental station at Kingsmead.

The 1920's

1920s: Mosaic identified in previously imported Argentinian varieties. Spreads to all commercial varieties except resistant Uba.

1926: Quarantine glasshouse built at the Botanic Gardens.

Co281, POJ2878 and others imported from India and SE Asia

1929: First report of Eldana in sugarcane at Mtubatuba

The 1930's

1930s: Streak virus ubiquitous in Uba: serious yield losses. Replaced by POJ and Co varieties.

Outbreaks of red locust and white-grub

1939: Severe infestation of Eldana on Umfolozi Flats in POJ2725 (highly susceptible)

POJ2878, POJ2714, Co301 also damaged, Co281 more resistant

The 1940's

Early 1940s: Eldana causes extensive damage on Umfolozi Flats, gradual increase in resistant Co281

1945: First record of brown rust in Africa (on variety Co301)

Late 1940's: Co281 crashes – RSD subsequently identified as the cause.Smut re-appears in Co301.

African sugar-cane borer (Eldana saccharina), which is known from Equatorial Guinea, Ghana, Mozambique, Sierra Leone and South Africa.

The 1950's

1952: RSD identified in South African sugar industry

1953: Eldana 'disappears' from Umfolosi (returns in 1974)

1955: Nematodes first recognised to be a problem in sandy soils

The 1960's

1960s: Smut serious in NCo310 in the north.

Numicia viridis (green leaf sucker) causing damage mainly in the northern irrigated areas.

Mosaic spreading in NCo376 in cool areas.

1968: First record of leaf scald in South Africa

The 1970's

1970: Eldana observed in NCo376 at Hluhluwe. "Eldana is unlikely to be a problem…" – Sugarcane Production Manual.

Early 1970's: Rust re-appears. Severe in N55/805.

Leaf scald identified as a hazard in the north.

Eldana becomes more widespread and a major pest north of the Tugela.

1975: First report of Eldana infestation south of Tugela River.

Exotic parasitoids introduced for biological control of eldana.

1978: Red rot found to be widespread in cooler areas.

Eldana recorded at Gledhow.

The 1980's

1980: Eldana found as far south as Port Shepstone.

Smut severe and getting out of control in NCo376 in the north.

Mosaic severe in NCo376 and NCo293 in cool areas.

RSD found to be widespread.

1982: Pest and Disease Committees formed

1983: Severe drought cuts production by 750 000 tons.

N12 found to be relatively drought and eldana resistant.

1984: Quarantine glasshouse moved from Botanic Gardens to Mt Edgecombe

1985: Record sugar production of 2,370 million tons

1988: N21 released – first eldana resistant variety.

Insect rearing unit opened at SASEX.

The 1990's

1990: Eldana begins to expand into the cooler Midlands areas

1992: First year of four-year drought reduces production to 1,5m tons

1993: Drought in 1993/94 season reduces production to 1,171 million tons.

Biotechnology facility fully operational at SASEX; research on Bt GMO begins.

1994: Yellow leaf syndrome observed in South Africa

1995: Drought restricts production to 1,67m tons of sugar in 1995/96

1996: Industry recovers from drought. Production increases to 2,2 million tons

1997: Sugarcane yellow leaf virus detected in northern irrigated region; subsequently found to be widespread

1998: Sour rot causing production losses in the Midlands.

Molecular methodology for detecting pathogens introduced into quarantine.

1999: Record crop in 1998/99 at 2,646 million tons of sugar.

In-house Bt GM cane tested at SASEX.

Another stem-borer threatens from Mozambique – *Chilo sacchariphagus*.

The 2000's

2000: Brown rust outbreak in newly released N29

2001: Record crop in 2000/2001 at 2,729 million tons of sugar

2002: N39 released for its eldana resistance

2003: Record crop of 2,763 million tons of sugar.

Fastac registered for Eldana control.

2004: First recommendation on use of silicon to increase resistance to eldana.

Bt GM cane, using a commercial gene, proof of concept demonstrated at SASRI.

Tissue culture introduced into quarantine procedure.

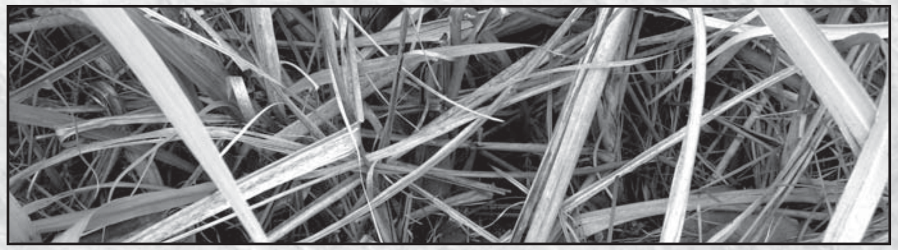
2005: First report of *Fulmekiola serrata*, sugarcane thrips in Umfolozi; subsequently widespread

2006: First report of *Sipha flava*, Yellow Sugarcane Aphid, in Morocco.

First report of Streak virus in newly released N44.

2007: Following the 2003-2005 dry spell, the 2006/07 season dips to the lowest level in 10 years with a production of 2,226 million tons of sugar

2008: First report of tawny rust in Swaziland; subsequently widespread in South Africa



The 2010's

2010: One year of drought.

Locust, grasshopper outbreak in Empangeni area.

Another rust threatens from West and Central Africa – Orange rust.

2011: Production drops to a 16 year low of 1.822 million tons of sugar

2013: First report of Yellow Sugarcane Aphid in Pongola; subsequently widespread

2014-2015: IPM Manual for eldana control produced and promoted throughout the industry

2015-2016: Severe eldana infestations due to drought.

N59 and N60 released for their eldana resistance.

New IPM friendly insecticides gain emergency registration for eldana control.

Outbreaks of white-grubs throughout the industry.

Stem borers *Busseola fusca* and *Chilo partellus* seen to be adapting to sugarcane.

Deployment of an array of pheromone traps for detecting *Chilo sacchariphagus*.

Mosaic and smut increase in severity in the irrigated areas due to the drought.

1800's 1900's 1910's 1920's 1930's 1940's 1950's 1960's 1970's 1980's 1990's 2000's 2010's