# FIRST OUTBREAK OF *ELDANA SACCHARINA* (LEPIDOPTERA: PYRALIDAE) IN SUGARCANE IN THE SOUTH-EAST LOWVELD OF ZIMBABWE

R MAZODZE[1], C NYANHETE[2] AND S CHIDOMA[3]

[1] *Zimbabwe Sugar Association Experiment Station, Private Bag 7006, Chiredzi, Zimbabwe*
[2] *Triangle Sugar Estate, Private Bag 801, Triangle, Zimbabwe*
[3] *Hippo Valley Estate, P. O. Box 1, Chiredzi, Zimbabwe*

## Abstract

A severe outbreak of the cane borer *Eldana saccharina* Walker (eldana) in two fields of sugarcane was reported in the Lowveld in March 1999. This is the first time eldana has been recorded on sugarcane in Zimbabwe. However, it is postulated that this pest, first recorded in sedges close to sugarcane in the Lowveld in 1987, was probably attracted to feed on stressed and carry-over cane following the 1991-92 and 1995-96 droughts, and the ensuing low levels of damage inflicted were not noticed. Two adjoining fields of 12-month old variety ZN1L and 11-month old variety N14 were severely affected and had incidences of 79 and 65% stalks bored respectively (n =2). Subsequent surveys undertaken to determine the extent of the problem in the industry indicated that the pest was limited mainly to one estate, with little or no incidences recorded on the others. On 30 April 1999 on one estate, 30% of surveyed fields recorded no damage, 56% had between 0 and 1,5% incidence, 12% had between 1,5 and 10%, and 2% had more than 10% stalks bored. This indicated that although eldana was widespread, most fields surveyed (86%) recorded little or no incidence of the pest. The variety ZN1L appears to be the most susceptible followed by N14, but differential susceptibilities among local varieties need further study. The survey results as at 30 April 1999 are presented, together with a discussion on varietal susceptibility and control.

## Introduction

The sugar industry in the south-east Lowveld of Zimbabwe, with about 42 000 ha under sugarcane, comprises four large estates, and settler and smallholder farmers. A severe outbreak of cane-borer was discovered in March 1999 in the Lowveld on two adjoining fields of 12-month old variety ZN1L and 11-month old variety N14.

On variety ZN1L, damage was so severe that stalks were breaking easily at the base where most damage occurred. The borer was identified as *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (eldana). It was first recorded in 1987 in the south-east Lowveld of Zimbabwe from the sedge, *Cyperus digitatus* Roxb. subsp. *auricomus* (Sieber) Kuk. (Cyperaceace) (Anon, 1987). To date, only the borer *Sesamia calamistis* Hamps. (Lepidoptera: Noctuidae) was known to attack sugarcane in Zimbabwe, although it did not assume pest status. *Eldana* is indigenous to Africa and is an economic pest of sugarcane in South Africa and Swaziland (Anon, 1970). Apart from sugarcane, maize and other cereal crops also are attacked in West and East Africa (Carnegie, 1974). Its presence in sugarcane in Zimbabwe was not unexpected, since it is likely to have always been present in the sedges which grow in wet areas and around irrigation dams close to sugarcane fields.

Following the discovery of the outbreak, surveys were conducted to establish the extent of the problem and to explain the outbreak. This paper reports the results of surveys and observations made, and includes a discussion on varietal susceptibility and control.

## Procedures

### *Initial outbreak and survey*

Two severely affected fields of N14 and ZN1L, and an adjoining field of NCo376 were observed to have borer damage. The initial survey procedure by the Zimbabwe Sugar Association Experiment Station (ZSAES) involved pacing every 10th row and inspecting 15 standing stalks at every 20th pace within the field. The two fields were then also surveyed by the estate and the two sets of data combined.

Ten damaged stalks selected at random were also removed from each of the three fields to determine the damage intensity, i.e. per cent internodes bored. In addition, five damaged and five undamaged stalks were taken at random from each field for weight and quality analysis.

### *Industry surveys*

Survey procedure was to pace every 10th row and remove one stalk at random at every 30th pace. The first randomly selected stalk was at the start of the cane line. Stalks were taken out of the field, and the underside of leaf sheaths inspected for pupae. Stalks were then split to check for larvae and pupae. The following were determined: % stalks bored, % internodes bored, cause of damage and numbers of larvae and pupae. At the time of writing, only cane fields aged 10 months and above were surveyed, except for two infested fields of ZN1L, aged about four months. Millyard surveys, which involve sampling one in every 10 bundles and inspecting only five stalks, have just begun at one mill.

*ZSAES*

At the ZSAES, where eldana was observed in small carry-over disease demonstration plots, every bored stalk was removed and the total number of stalks per variety (plot) counted.

*Alternative hosts and parasitoids*

Other activities have included checking for the presence of the borer in the sedge (*C. digitatus*) and in sweet sorghum and maize. Eldana larvae and pupae were also collected for rearing on an artificial diet (Graham and Conlong, 1988). The aim is to recover and identify any parasitoids.

## Results

*Initial outbreak*

Borer incidences and damage intensities observed in the three adjoining fields are shown in Table 1. The variety ZN1L was the worst affected, with 76% stalks bored and a damage intensity of 42% internodes bored, followed by N14 which recorded 65 and 23%, respectively. Damage in the younger NCo376 field was lowest. Examination of the most severely damaged fields showed extensive and intensive damage to these crops aged about 12 months. One eldana infested four- month old field of ZN1L on the same section had 46% stalks bored. Section 7 fields are close to the dam where eldana was found in sedge (*C. digitatus*) in 1987. Soils are sandy loams derived from paragneiss.

Weights of damaged stalks of ZN1L and NCo376 were lower than those of undamaged stalks, although in N14 the damaged stalks were heavier than the undamaged ones (Table 2). However, quality as measured by brix % cane, pol % cane, purity and erc % was lower in damaged stalks than undamaged stalks for all three varieties. Damaged stalks had a higher fibre % than undamaged stalks. When further samples of damaged stalks were taken, and bored internodes cut out and analysed separately from the unaffected internodes, the damaged parts of stalks had higher fibre and lower quality than the undamaged portions for all the three varieties (Table 3). Affected internodes contained little or no juice.

*Industry surveys (as at 30 April 1999)*

The field surveys, which concentrated on cane of ten months of age and older, indicated that eldana is becoming more widespread, albeit at low levels in most areas. On one estate 29% of fields were surveyed. Of these fields 30% recorded no eldana, 56% had between 0 and 1,5% stalks bored, 12% had between 1,5 and 10% and 2% had more than 10% stalks bored (high damage category). Of the eight fields in the high damage category, the highest levels of damage were recorded in two ZN1L fields, which had incidences of 79 and 46%, and three N14 fields with incidences of 32, 65 and 25%. The fields in the high damage category were situated in different parts of the estate.

At another estate, only one pupa was found in a four-month

**Table 1. Incidence and severity of initial outbreak of *E. saccharina*.**

| Field | Variety | Age (months) | % stalks damaged* | Mean % internodes bored |
|---|---|---|---|---|
| 1 | ZN1L | 12 | 79 | 42 |
| 2 | N14 | 11 | 65 | 23 |
| 3 | NCo376 | 8 | 4 | 24 |

* values are means from two estimates each comprising 225 stalks.

**Table 2. Weight and quality of undamaged and damaged stalks from three adjoining fields.**

| Measure | Undamaged | | | Damaged | | | % difference (% of undamaged) | | |
|---|---|---|---|---|---|---|---|---|---|
| | ZN1L | N14 | NCo376 | ZN1L | N14 | NCo376 | ZN1L | N14 | NCo376 |
| Weight (g/stalk) | 1 036 | 1 192 | 876 | 924 | 1 548 | 656 | -11 | +30 | -25 |
| Fibre % | 11,6 | 11,5 | 11,3 | 13,3 | 12,6 | 11,5 | +15 | +9 | +2 |
| Brix % cane | 13,4 | 12,1 | 12,6 | 12,3 | 11,4 | 11,4 | -8 | -6 | -9 |
| Pol % cane | 11,1 | 10,3 | 10,3 | 10,2 | 8,8 | 8,7 | -8 | -14 | -15 |
| Purity | 82,8 | 84,9 | 81,7 | 82,5 | 77,3 | 6,1 | -0 | -9 | -7 |
| ERC % cane | 9,5 | 8,9 | 8,7 | 8,6 | 7,1 | 7,0 | -9 | -20 | -19 |
| ERC (g/stalk) | 98,4 | 106,1 | 76,2 | 79,5 | 110,0 | 45,9 | -19 | +4 | -40 |

**Table 3. Quality of undamaged and damaged internodes of infested stalks from three fields.**

| Measure | Undamaged | | | Damaged | | | % difference (% of undamaged) | | |
|---|---|---|---|---|---|---|---|---|---|
| | ZN1L | N14 | NCo376 | ZN1L | N14 | NCo376 | ZN1L | N14 | NCo376 |
| Fibre % | 10,4 | 9,7 | 9,6 | 14,2 | 11,7 | 12,8 | +36 | +21 | +33 |
| Pol % cane | 13,0 | 11,6 | 10,5 | 7,5 | 7,2 | 6,9 | -42 | -8 | -34 |
| ERC % cane | 11,3 | 10,1 | 8,7 | 5,8 | 5,5 | 5,0 | -49 | -45 | -42 |

**Table 4. Incidences and mean % internodes bored at ZSAES disease demonstration plots.**

| Variety | Age (months) | % stalks bored | % stalks bored, with eldana present | % stalks bored, with sesamia present | Mean % internodes bored | |
|---|---|---|---|---|---|---|
| | | | | | Eldana | Sesamia |
| N14 | 18 | 2,6 | 0,5 | 0,0 | 12,1 | 9,2 |
| NCo376 | 18 | 0,4 | 0,0 | 0,1 | N/A | 13,0 |
| CP 72-1312 | 18 | 1,4 | 0,2 | 0,0 | 14,7 | N/A |
| ZN1L | 3,5 | 1,5 | 0,6 | 0,0 | 26,3 | N/A |

old NCo376 field, which was close to a dam around which was found the sedge (*C. digitatus*) that was heavily infested with eldana. Millyard inspections revealed an infestation of N14 on a private farm. Part of the same field which had not yet been harvested had 24% stalks bored by eldana. Lower damage levels were recorded in fields close to this one and they had the following incidences in order of magnitude (variety is indicated first): CP72-1312 (10%), CP72-1312 (9%), N14 (5%) and NCo376 (4%). No eldana were found at MDC and Mkwasine Estate.

At ZSAES, eldana was found only in the disease demonstration plots, where cane had been carried over (Table 4). Again, the varieties ZN1L and N14 were the worst affected.

*Other hosts of eldana*

During this outbreak eldana larvae were recovered from the sedge, *Cyperus digitatus* Roxb. subsp. *auricomus* (Sieber) Kuk. (Cyperaceae), on one estate. One eldana specimen was also recovered from sweet sorghum stubble. No eldana were found in maize at the silking stage; however, the search was not extensive.

*Parasites and predators*

Ants (Formicidae), although not seen feeding on eldana, were observed in many fields on the ground and on the stalks both outside and inside the damage holes. In cases where ants were inside the damage holes, no eldana larvae were found. However, detailed observations have not been carried out.

*Pest management*

The following recommendations for minimizing damage caused by eldana are being implemented and are based on those used by SASEX.

- Conduct surveys and cut early. Based on survey results, start with the most heavily infested fields. Larvae that survive the pre-harvest burn will be crushed at the mill.
- In infested areas avoid moisture stress or prolonged drying-off periods.
- Field hygiene: Where the eldana infestion is severe burn the fields before harvest as well as tops, trash and stalks left after harvest. Fields must be left clean. Cutting must be done at ground level to minimise the number of borers left in the field. Young shoots attacked ('dead hearts') can be cut out at the base at regular intervals and placed in plastic bags for burning.
- No carry-over cane should be allowed. Plant and ratoon crops generally to be cut at 14 and 12 months of age or younger, respectively. Smaill (1978) found that the intensity of eldana infestations increases with cane age. Plough-out is recommended where a severe infestation occurs.
- Use varieties that are more resistant to eldana. The high fibre varieties are often more resistant while the high quality varieties tend to be more susceptible to eldana.
- Plant only clean (uninfested) seedcane which has been inspected by ZSAES, or hot water treat the seedcane (50°C for 30 minutes) before planting. This hot water treatment is insufficient for RSD control but would generally not adversely affect germination. Dipping setts in diluted insecticide (such as phoxim) is an effective alternative but this should be used only with advice from ZSAES.
- Seedcane can only be moved from one section or estate to another after inspection of the seed crop. A movement permit is issued by ZSAES.
- Apply recommended rates of nitrogen. Over-application increases susceptibility ([1]personal communication).
- Crops must not be subjected to moisture stress except during drying-off, which should be reduced in infested cane.
- Pre-trashing would help to reduce the number of eggs laid in the field but it is labour intensive and it is best conducted in conjunction with known moth peaks.

Field spraying of insecticides has not been recommended as this is likely to worsen the situation by killing natural enemies of eldana (Carnegie, 1977).

## Discussion

*Initial outbreak*

Differences in borer incidence and severity of damage observed in the three adjoining fields are difficult to ascribe solely to variety because of the age differences. However, ZN1L is likely to be the most susceptible of the three varieties, since it had the highest damage intensity of 42% internodes bored compared with 23 and 24% for N14 and NCo376, respectively. Also,wind was able to break ZN1L at the damaged points more easily than those of N14. Despite the high damage levels in the ZN1L and N14 fields (79 and 65% respectively), the adjoining NCo376 field had a lower level of 4%. This could imply that NCo376 is less susceptible, or it could be that the crop was younger and the infestation would increase with time. The apparent slow spread of the infestation to other adjoining fields also indicates that the pest is a weak flyer; and according to Carnegie *et al.* (1976)

[1] Mr GW Leslie, Head Entmology Department, SASEX

this is because moths usually lay eggs close to the cocoons from which they emerge, resulting in young larvae boring into the same or neighbouring stalks. The occurrence of a severe infestation on a four month old ZN1L crop indicates that the pest was present in the previous crop(s) but was not noticed. The susceptibilities of the three varieties tended to be associated with higher erc % cane and lower fibre %. Susceptibility to borer damage tends to be inversely related to fibre % cane ([2]personal communication). Further work on assessing the differential susceptibilities of varieties is required.

Since only one sample of five stalks of damaged and undamaged cane was weighed, no statistically valid conclusions can be drawn from the results. However, in South Africa, Smaill and Carnegie (1979) found that there was no significant reduction in cane yield as a result of damage by eldana. The lower juice quality of damaged compared to undamaged stalks obtained agrees with their observations. In order to estimate crop loss, a large number of samples would need to be analysed for different infestation levels and perhaps for the different varieties grown in the industry. Smaill and Carnegie (1979) estimated that a 0,1% loss in recoverable sugar occurs for every 1% stalks damaged. A similar relationship needs to be determined under local conditions. Damaged stalks had higher fibre and lower sucrose than the undamaged stalks as larvae feed on the sugars which results in a relative increase in fibre. The comparison of fibre and sucrose contents of bored and undamaged internodes from the same stalks may be explained similarly, or additionally, by the fact that most of the damaged internodes were the lower ones, which would naturally have more fibre and more sugar than the top internodes because they develop earlier.

*Industry surveys*

Although this is the first time eldana has been observed in sugarcane in Zimbabwe, the fact that it is widespread indicates strongly that it has been in cane for at least a few years, probably as a result of drought. This is not surprising since it is indigenous to Africa and was recorded on *C. digitatus* in the Lowveld in 1987. This sedge is common around irrigation storage dams and along drainage lines and permanent water courses, which are abundant in the lowveld. The droughts of 1991-92 and 1995-96 which created stress conditions and carry-over cane in 1995-96, probably led the pest to adapt to feeding on cane. Eldana is thought to adapt to feeding on sugarcane once it has been in contact with it for some time (Carnegie, 1974) and this may have started during the severe 1991-92 drought. Carry-over cane is likely to be associated with eldana since at ZSAES it was only found where there was carry-over cane. Heavy infestations were also found to be associated with stand-over cane in South Africa (Carnegie, 1974). The unusually warm winter in 1998 may also have encouraged the build-up of the pest. Most fields in the high damage category were planted to ZN1L and N14, and these varieties only occupy about 1 and 20% respectively, of the sugarcane planted in the industry, whereas about 70% is planted to NCo376. This again strongly indicates that ZN1L and N14 may be more susceptible than NCo376 but further evaluations are required.

The differences in incidence and damage intensity between varieties infested at ZSAES may not reflect true varietal differences in susceptibility since they were of different ages. Since most cane was old and few sesamia larvae were found, damage was attributed mainly to eldana. However, the results indicate that ZN1L (youngest) and N14 were the most susceptible. Since these varieties were also found to be heavily attacked in the rest of the industry, they are possibly more susceptible to eldana than NCo376. It has now been observed that sesamia tunnels into the cane in long, straight burrows, whereas eldana burrows are shorter and often winding. Further observations are necessary to compare the nature of the damage caused by these pests and how this differs between varieties. It may thus in the future be possible to separate the two in the absence of larvae or pupae in or on the stalk. More data will be gathered during the course of the current milling season by way of routine field and millyard surveys.

*Biology, alternative hosts and natural enemies*

All stages of the insect were present, confirming that overlapping generations occur, as is the case in South Africa (Carnegie, 1974). More work on identifying alternative hosts of eldana needs to be carried out. Collections and cultures of eldana need to be undertaken regularly to identify parasitoids. Further observations of ant activity are necessary, since they are known predators in South Africa (Leslie, 1977).

## Conclusions

Eldana is likely to remain a pest of sugarcane in the Lowveld and levels are likely to fluctuate, depending on climatic conditions and the level of management. It is imperative that monthly scouting and earlier milling is used to reduce the build-up and spread of this pest within the industry. The area grown to ZN1L should not be expanded and consideration should be given to replanting with NCo376 or with varieties which are less susceptible, e.g. N29 in areas where the pest becomes established. It is imperative that there is no standover cane in these areas and that cane is not subjected to moisture stress or long drying-off periods. Plough-outs are required where infestations are high. Seedcane is to be inspected for eldana and a movement permit issued only to eldana-free seedcane (zero tolerance at this stage is important) before being transported to another section, farm or estate. Hot water treatment is recommended for seedcane from an eldana infested area even when it is found to be free of damage.

The breeding programme must now take into consideration the threat from eldana and varieties which are more tolerant than NCo376 will have to be selected for within the programme.

[2] Mr RS Bond, Assistant Director and Mr GW Leslie, Head Entmology Department, SASEX

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# THE SPOTTED SUGARCANE BORER, *CHILO SACCHARIPHAGUS* (LEPIDOPTERA: PYRALIDAE: CRAMBINAE), IN MOZAMBIQUE

MJ WAY[1] AND PET TURNER[2]

[1] *South African Sugar Association Experiment Station, P/B X02, Mount Edgecombe, 4300 South Africa*
[2] *Cluster Box 1443, Forest Hills/Kloof, 3610, South Africa*

## Abstract

The spotted sugarcane borer, *Chilo sacchariphagus* Bojer was recently collected in sugarcane in Mozambique. Considerable stalk damage was recorded. This paper discusses its distribution, pest status, biology, host plants and control options.

## Introduction

In August 1998, larvae of the Crambine *Chilo sacchariphagus* Bojer (commonly known as spotted stalk borer) were collected from sugarcane at Mafambisse estate in Mozambique (Way, 1998). Past unsubstantiated records (van Rensburg *et al.*, 1989; Bailey and Wood, 1991; Leslie, 1993) indicate that this borer has probably been present in Mozambique for at least the past eight years. The presence of the borer in Mozambique sugarcane poses a potential threat to this reviving industry.

Larvae collected at Mafambisse (34° 10′ E, 19° 20′ S) were reared to adults on artificial diet medium (Graham and Conlong, 1988) in plastic vials (80 x 20 mm). Emerged adults were sent to the Identification Service, CABI Bioscience in the United Kingdom (incorporating the International Institute of Entomology), where they were identified by K. Tuck as *C. sacchariphagus*. Voucher specimens were housed at the Biosystematics Division: Entomology Department of the Agricultural Research Council (Plant Protection Research Institute, South Africa).

## Distribution

*C. sacchariphagus* has been recorded from Indonesia, Borneo, Java, Bali, Sumatra, Celebes, Singapore, Malaysia, Philippines, India, Taiwan, China, Madagascar, Mauritius and Reunion (Bleszynski, 1970), and now Mozambique. Its distribution in Mozambique is unknown, and it has not been positively recorded from any countries adjacent to Mozambique, including South Africa, where the regular surveys in all sugarcane areas for *Eldana saccharina* Walker (Lepidoptera: Pyralidae) would have revealed its presence. In addition, synthetic pheromone traps developed in Mauritius to monitor *C. sacchariphagus* were set up at four sites along the borders between Swaziland and Mozambique, and South Africa and Mozambique, but these attracted no moths (Way, 1997).

## Pest Status

*C. sacchariphagus* is a major pest of sugarcane in Indonesia, Mauritius, India, Taiwan and China (Bleszynski, 1970). Rajabalee *et al.* (1990) give estimates of losses attributed to this pest in Mauritius. At Mafambisse, infestation levels over the past three years declined from 6,0 to 4,7 and 3,4 larvae per 100 stalks while damage remained constant at 4,57% of the stalk length. In 1998, larvae were present on 10 out of the 11 sections on the estate, and losses due to the borer on the 6 410 hectare estate were estimated at between 14 000 and 35 000 tons cane (Turner, 1999).

## Biology

Williams (1983) details the biology of *C. sacchariphagus* in Mauritius, and some of this information is summarised for comparison with observations made at Mafambisse. Adults emerge and mate at dusk on the night of emergence. Oviposition (300 to 850 eggs) occurs on green leaf blades of sugarcane at night. First instar larvae bore into the leaf midrib, through the spindle blades, or on the leaf surface. The latter results in the formation of 'windows' in the leaves, and spindle damage causes characteristic 'shot-holes' in open leaves. Older larvae bore into the sides of shoots, and in very young cane tunnelling causes destruction of the growing tip, leading to dead hearts. In older cane, feeding occurs on tissue below the growing point, which may cause side shooting or stalk destruction if extensive tunnelling occurs.

At Mafambisse no leaf damage was observed. Tunnelling was found on the top sections of stalks in 11 to 14 month old cane. Limited side shooting was observed. Pupation occurred on the lower leaf sheath surface or, as observed at Mafambisse, at the exit of a stem boring.

## Host plants

Only sugarcane has been surveyed for *C. sacchariphagus* at Mafambisse. In Mauritius, *C. sacchariphagus* has been recorded mostly from sugarcane (Saccharum hybrids), and occasionally from maize (*Zea mays* L) where it is not a major pest (Williams, 1983). According to Williams (1983), other graminaceous host plants recorded by Hill (1983) remain unsubstantiated in Mauritius.

## Control options

In its country of origin many parasitoids attack this borer (Kuniata, 1994). The Mauritian sugar industry have to an extent used this information and embarked on a classical biological control programme in an effort to control *C. sacchariphagus* in their cane. Natural parasitoids from a number of other countries have been introduced to combat the pest (Williams, 1983; Ganeshan and Rajabalee, 1997; Leslie, 1994). Several have become established (Ganeshan and Rajabalee, 1997) including *Xanthopimpla stemmator* (Thunberg) (Hymenoptera: Ichneumonidae), which is currently being mass reared at SASEX. A classical biological control programme for Mozambique is thus feasible and should be considered. Cultural control options were not considered feasible in Mauritius (Williams, 1983), and chemical control against this pest was not recommended (Williams, 1983). There is no information on varieties resistant to *C. sacchariphagus*. It is thus difficult at this stage to recommend any of these other options until further research into the biology of this insect in Mozambique has been completed, and the susceptibility of the available sugarcane varieties to this insect has been assessed. Varietal resistance trials should be completed when possible.

## Conclusion

The sugarcane stalk borer, *C. sacchariphagus* is definitely present in Mozambique. This insect is a pest in sugarcane in Mauritius, where a classical biological control programme has been in place for many years. A similar option may help reduce borer populations, and concomitant losses, at Mafambisse sugarcane estate in Mozambique.

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# AN UNUSUAL STALK ROT OF SUGARCANE CAUSED BY *PHAEOCYTOSTROMA SACCHARI* IN THE KWAZULU-NATAL MIDLANDS

JL GOODALL[1], SA MCFARLANE[1] AND C ROUX[2]

[1]*SASA Experiment Station, P/Bag X02, Mount Edgecombe, 4300*
[2]*National Collection of Fungi, Biosystematics Division, P/Bag X134, Pretoria, 0001*

**Abstract**

A severe and unusual stalk rot was first observed in the KwaZulu-Natal Midlands in October 1998 after prolonged dry conditions during winter and spring. The rot was subsequently found to be common in many fields of a number of varieties. In a survey in the area, 64 out of 137 fields were found to be affected to some degree. An orange-brown rot occurred in more than 50% of the internodes in most of the affected stalks. The rot occurred in both young and old cane of varieties N12, N16 and N21. The purity of infected stalks was reduced, and this caused a number of cane consignments to be rejected by the mills. The dominant fungal pathogen isolated from the affected stalks was identified as *Phaeocytostroma sacchari* (Ellis and Everh.) Sutton. This pathogen also causes rind disease, a common but minor infection of the rind of over-mature and moribund stalks, but one that has been reported to progress to cause severe stalk rotting, if mature cane is subjected to prolonged poor growing conditions such as drought. This is the first record of rind disease progressing to cause a severe stalk rot in the South African sugar industry.

*Keywords:* Sugarcane, stalk rot, *Phaeocytostroma sacchari*, rind disease

## Introduction

*Phaeocytostroma sacchari* (Ellis and Everh.) Sutton causes rind disease, which is a common but usually minor condition that affects cane stalks weakened by insect injury or other wounds, cane growing under unfavourable conditions such as drought, and over-mature and moribund stalks (Johnston, 1917; Abbott *et al.*, 1964). The diagnostic symptom of rind disease is the pustules, which appear as coiled, black masses of spores under humid conditions. The pustules break through the surface of the rind of affected stalks, and can also be present on leaf sheaths and midribs (Abbott *et al.*, 1964).

When there is severe drought, particularly late in the growing season, rind disease may develop into a stalk rot, which can cause substantial sugar losses, particularly in susceptible varieties (Liu *et al.*, 1977). Under these adverse conditions an internal rotting appears in the mature portions of growing stalks, followed by a discolouration of the rind and development of pustules under appropriate conditions. If the drought persists, the portion of the stalk above the infected internodes may continue to deteriorate and become desiccated. In severe infections, rotting can extend into the stubble and kill the entire stool (Abbott *et al.*, 1964). The stalk rot phase of the disease is uncommon and had not previously been reported from South Africa.

In October 1998, an unusual and severe stalk rot of unknown identity was reported in a field of 18 month old cane of variety N12 in the Midlands South extension area. This rot was subsequently found to be common in other fields in the area. A number of infected cane consignments were rejected by the mills because of low purity.

The aims of this study were to conduct disease surveys in the Midlands to estimate the extent of the unusual stalk rot and to identify the causal organism.

## Materials and Methods

### *Field survey*

A survey was conducted in the Midlands South extension area, where the disease was first reported. A total of 137 fields on 57 farms were sampled in October and November 1998. Most of the surveying was conducted by the field inspection team of the Local Pest and Disease Control Committee (LP&DCC). Samples consisting of 100 randomly selected stalks were taken from each field. The stalks were split and examined for borer damage and rotting. Stalk rotting was identified as being due either to red rot (*Glomerella tucumanensis*), based on its characteristic symptoms, or 'new' stalk rot. The latter was usually accompanied by a distinctive sour odour.

Further stalk samples were taken from 15 affected fields and examined in the Pathology laboratory at the SASA Experiment Station (SASEX). These stalks were examined for external damage and symptoms of red rot and the new stalk rot. The number of internodes affected by the stalk rot was also recorded.

### *Rainfall*

Rainfall figures were supplied by SASEX from data collected from meteorological stations in the Midlands area.

*Pathogen isolation*

Between two and five stalks were taken from each of the samples that were brought to SASEX. The stalks were split in half longitudinally to assess the extent of rotting and 1 $cm^3$ pieces of internal internodal tissue were cut from the interface between infected and apparently healthy tissue. The pieces were surface sterilised by soaking in 0,35% sodium hypochlorite (10% 'Jik') for five minutes and the outer surfaces were aseptically removed. The remaining tissue pieces (approximately 0,5 $cm^3$) were again surface sterilised in sodium hypochlorite for 2 minutes, air dried on sterile tissue paper and dipped in 70% ethanol for 2 minutes before flaming and plating onto potato dextrose agar (PDA). Mycelium growing from the tissue sections was immediately transferred onto fresh PDA. All petri dishes were kept on a laboratory bench at 20-25°C under natural light. Most of the cultures appeared to be *Phaoecytostroma sacchari*, and some a *Fusarium* sp.

*Pathogenicity tests*

Stalks of sugarcane variety N12 were collected from the field and cut into approximately 10 cm long segments that were quartered longitudinally. The pieces were placed into test tubes and autoclaved twice at 121°C for 20 minutes. Each sterile stalk piece was then inoculated with a disc of agar cut from each culture. The tubes were left on a laboratory bench and examined periodically.

The marcotting procedure used by the SASEX Plant Breeding Department (Anon., 1975; Nuss, 1977) was used to obtain single, live sugarcane stalks that could be inoculated with fungal cultures and grown in the glasshouse. Stalks of varieties N12 and NCo376 were cut just above the soil surface in the field. The basal part of each stalk was placed in and through a metal cylinder (40 cm long, 15 cm diam.) that was then filled with a growing medium of composted bagasse and filtercake. Approximately 15 cm of the stalk extended below the cylinder and this was placed in a trough containing a sulphur dioxide solution. Once roots had developed within the cylinder, the trough was removed and the stalk was watered through the growing medium.

A 1,5 mm drill bit was used to make a horizontal hole in each marcotted stalk, midway between the nodes of the first full internode above the growing medium. The hole was drilled horizontally to the centre of the stalk tissue. Fruiting bodies (sclerotia) from ten cultures of *P. sacchari* and spores from one culture of the *Fusarium* sp were suspended in 5 ml sterile distilled water in McCartney bottles. The bottles were vortexed to release spores from the sclerotia. Each plant was inoculated with 0,5 ml of spore suspension using a 1 ml hypodermic needle. The holes were then sealed with parafilm.

This experiment consisted of 12 treatments, each replicated four times for each variety. A total of 80 stalks were inoculated with *P. sacchari*. Control stalks were injected with sterile distilled water.

After inoculation the plants were watered daily for five weeks and then water was withheld for two weeks. After the seven week period external symptoms were noted and the stalks were cut in half longitudinally and the number of infected internodes counted. Pathogens that has colonised the stalk tissues of variety N12 were identified as described above under čPathogen isolationí.

## Results and Discussion

*Field survey*

Sixty-four (47%) of the 137 fields sampled were infected with stalk rot to some degree (Table 1). Forty-one of the 64 affected fields had less than 10% infected stalks. Seven fields contained between 25 and 50% affected stalks, in nine fields more than 50% of the stalks were infected, and in one field all the stalks sampled were infected. In most cases, not all the stalks in one stool were infected.

**Table 1. Number of fields and percent stalks affected by stalk rot in the Midlands South extension area.**

| % stalks with rotting | No. of fields |
|---|---|
| 0 | 73 |
| 1-5 | 30 |
| 6-10 | 11 |
| 11-25 | 7 |
| 26-50 | 7 |
| 51-75 | 6 |
| 76-100 | 3 |
| Total fields | 137 |

The internal tissues of affected stalks were red/orange in colour (Figure 1) and had a distinctive sour odour. The colour was easily distinguished from the brighter red rotting caused by red rot. In most stalks, cushiony masses of mycelium were present, as described by Martin (1938). Hair-like masses of spores were visible emerging from pustules on the rind and leaf sheaths of some stalks (Figure 2). The purity of infected stalks was reduced, causing a number of cane consignments to be rejected by the mills.

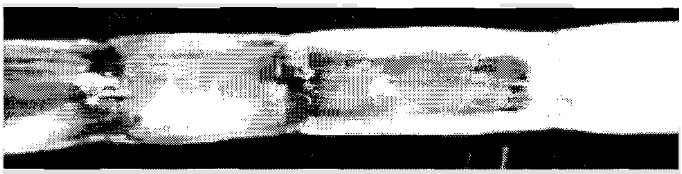

**Figure 1.** Internal stalk rotting of N12 caused by *Phaeocytostroma sacchari.*

Variety N12 is extensively grown in the Midlands South area and therefore it constituted a large proportion of the fields sampled (Table 2). The stalk rot was not limited to N12, and varieties N16, N21 and NCo376 also had symptoms. Of the samples examined at SASEX, a mean of 73% of the internodes in affected stalks were damaged (Table 3).

Infection was not associated with borer or other damage. In most stalks, infection appeared to have entered the stalk in the region of the third or fourth internode, possibly through the leaf scars, buds or root primordia.

**Figure 2.** Hair-like spore masses emerging from rotted stalks.

**Table 2. Incidence of stalk rot in different varieties grown in the Midlands South extension area.**

| Variety | No. fields sampled | No. (and %) fields with stalk rot |
|---|---|---|
| N11 | 1 | 0 (0) |
| N12 | 111 | 55 (50) |
| N16 | 17 | 5 (29) |
| N21 | 3 | 2 (67) |
| NCo376 | 5 | 2 (40) |
| Total fields | 137 | - |

**Table 3. Percent internodes damaged in stalks found to be infected with stalk rot.**

| % internodes affected | No. of samples |
|---|---|
| 1-25 | 0 |
| 26-50 | 1 |
| 51-75 | 6 |
| 76-100 | 8 |
| Total samples | 15 |

By February 1999, all affected fields had been harvested. A 600 stalk sample taken at that time from a field of N12 showed that the stalk rot was still present in the area but at low levels, with only 1,6% of the stalks sampled being affected. Further surveys of previously affected fields are planned for the coming season to determine whether the disease is still prevalent.

*Rainfall data*

The Midlands area received below average rainfall from June to November 1998 (Figure 3). September was particularly dry, with only 24 mm (39% LTM) being recorded at three meteorological stations in the Midlands South area and 32 mm (46% LTM) recorded at six sites in the Midlands North area. Prolonged periods of drought are reported to have caused severe outbreaks of stalk rot caused by *P. sacchari* in Queensland (Abbott *et al.*, 1964) and Hawaii (Anon, 1958). The prolonged and unusually intense drought that occurred in the Midlands region of the South African sugar industry in mid-1998 is therefore thought to be the main reason that *P. sacchari*, usually regarded as a common but minor pathogen, caused severe damage to cane in 1998.

*Pathogen isolation and identification*

Sixty-four fungal cultures were isolated, seven of which were identified as a *Fusarium* spp. and 57 as *P. sacchari*, as confirmed by one of the authors (CR) at the National Collection of Fungi Biosystemics Division. *Fusarium sp.* and *P. sacchari* occurred together on four tissue segments. In pure culture on PDA, the mycelium of *P. sacchari* was dark grey. Black, spherical fruiting bodies (conidiomata) 1-2 mm in diameter, appeared in culture after seven days. When the conidiomata were viewed under the light microscope a number of pycnidia were seen in each. Each pycnidium contained masses of one-celled, light brown, cylindrical spores measuring 10-13,8 µm x 3,8 µm (Figure 4). Square crystals of calcium oxalate, measuring between 10 and 12,5 µm, were also observed.

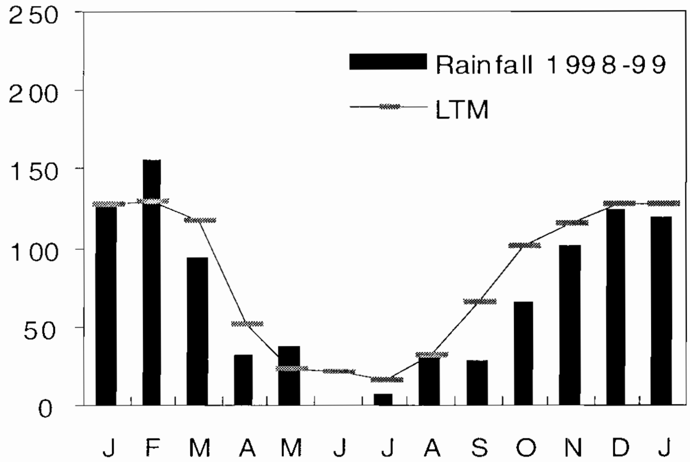


**Figure 3.** Mean monthly rainfall and long term mean rainfall (LTM) in the Midlands region of KwaZulu-Natal, January 1998 - January 1999 (mm).

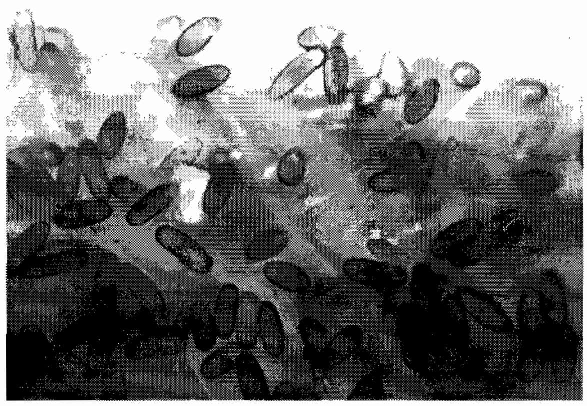

Figure 4. Spores of P. *sacchari.*

*Pathogenicity tests*

In the laboratory, following inoculation and incubation at room temperature, all stalk sections inoculated with *P. sacchari* were soon enveloped by mycelium. Initially, white spots developed on the rind. A few weeks later black spore masses emerged from these areas (Figure 5). Some of the spore masses were coiled, as described by Abbott *et al.* (1964). This confirmed that the predominant fungus isolated from the rotted portions of the stalks was *P. sacchari*, the causal organism of rind disease. The stalk pieces inoculated with *Fusarium* were covered with a dark purple mycelium.

**Figure 5.** Black spore masses of spores of P. sacchari emerging from pustules on rotted stalks after inoculation.

In the glasshouse experiment, when most stalks inoculated with *P. sacchari* and the untreated controls were split, only the inoculated internodes were reddened. This discolouration spread to the upper internodes in only nine of the inoculated stalks (six stalks had two infected internodes, two stalks had three infected internodes and one stalk had six infected internodes). This result showed that the inoculation technique was unsuccessful in most stalks. This may have been due to a number of factors, including the possibility that the inoculum density of the fungal spore suspension may have been too low. It is also probable the stalks were not stressed long enough after inoculation for the infection to spread throughout the stalk. Further experiments may be necessary to determine the length of drying-off period for symptoms to occur.

It may be necessary to evaluate other methods for pathogenicity tests for *P. sacchari*. For example, Liu *et al.* (1977) successfully inoculated four-budded setts by spraying spores onto the stalk surface before covering with a plastic bag for two to three days; after ten days 93% of the varieties were rated as having an intermediate or susceptible reaction to the fungus.

Twenty days after the reddened, inoculated internodes or uppermost infected internodes of N12 from the glasshouse experiment were quartered, surface sterilised and placed into test tubes, most of the 40 sections that had been inoculated with *P. sacchari* showed symptoms of rind disease. This result confirms that the fungus was present in the actively growing marcotted stalks, although conditions in the glasshouse were not conducive to the growth and spread of the fungus within the stalks.

## Conclusions

A severe stalk rot occurred in many sugarcane fields in the KwaZulu-Natal Midlands in late 1998, after prolonged dry conditions during the preceding winter and spring months, and caused substantial economic damage. The stalk rot was caused by the fungal pathogen *Phaeocytostroma sacchari*. This pathogen also causes rind disease of sugarcane, a common but usually minor infection of the rind of over-mature or moribund stalks. The outbreak of severe stalk rot in the Midlands was the first record of this phase of the disease in South Africa, and confirms the few published reports that *P. sacchari* can cause severe damage to sugarcane crops that are subjected to prolonged poor growing conditions, such as drought. This new outbreak was unusual in that it was common, it affected a number of varieties, and it affected crops with a wide range of ages and was not confined to over-mature cane.

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# THE INCIDENCE AND EFFECTS OF RATOON STUNTING DISEASE OF SUGARCANE IN SOUTHERN AND CENTRAL AFRICA

RA BAILEY AND SA McFARLANE

*South African Sugar Association Experiment Station, P/Bag X02, Mount Edgecombe 4300*

## Abstract

Surveys have shown that ratoon stunting disease (RSD) is common in most sugar industries in southern and central Africa. In South Africa in 1998, approximately 12% of commercial cane fields contained some level of RSD infection, but the mean number of stalks infected was low. The most recent estimates of the numbers of infected fields in other industries are: Swaziland 30%; Zambia 50%; Kenya, Malawi, Uganda and Zimbabwe 60-90%; Tanzania and Mafambisse estate in Mozambique 100%. In some of these industries the majority of stalks within fields are infected. Field experiments have shown that RSD can cause reductions in yield of 15-30% under good irrigated conditions, and 20-40% under average rainfed growing conditions in varieties that are widely grown in Africa. By integrating survey data and experiment results, it is estimated that yield losses due to RSD in South Africa are equivalent to approximately 1% of current production, but that losses of 10-20% or even greater are probable in some of the other industries.

Minimising the effects of RSD on production should be a priority throughout the region. To achieve this, attention must be given to two main factors. Firstly, the consistent production of healthy seedcane through well-managed schemes incorporating hot water treatment and, secondly, improving the efficiency of stubble destruction before fields are replanted, to prevent RSD surviving in infected volunteer plants and spreading to new plantings. In many areas this will require longer breaks from cane before fields are replanted.

*Key words*: ratoon stunting disease, RSD, hot water treatment, yield loss, *Clavibacter*

## Introduction

The South African Sugar Association Experiment Station (SASEX) has conducted large scale surveys of RSD incidence in the South African sugar industry since 1977. A number of other sugar industries in Africa have made use of the SASEX diagnostic service. Survey data from the mid to late 1990s are available from Swaziland, Malawi, Zambia, Kenya, Tanzania, Uganda and Mozambique. Information on the status of RSD in Zimbabwe from 1996 to 1998 is available from surveys by the Zimbabwe Sugar Association Experiment Station (ZSAES). From the time of the earliest surveys it was apparent that high levels of RSD occurred in certain parts of the South African sugar industry and in most of the other industries.

In most sugarcane industries in Africa production is based mainly on SASEX-bred varieties. The effects of RSD on these varieties are routinely determined by SASEX in field experiments. The magnitude of losses in many varieties when infected by RSD is known to be large under both rainfed and irrigated conditions.

An important feature of sugarcane production in most African sugar industries is that, traditionally, only short breaks from cane, sometimes as little as two to four weeks, are applied between destroying old crops and replanting fields. Consequently, numerous volunteer plants survive from old crops into new plantings.

This paper summarises the status of RSD in industries where surveys have been conducted. By considering survey data together with estimates of yield loss in controlled experiments, estimates of the effect of RSD on production in different countries are possible. These estimates are presented and key factors necessary to reduce the economic effects of RSD are identified.

## Survey methods

Surveys of RSD incidence in South Africa have been conducted by SASEX since 1977. Currently, samples from approximately 7 000 fields are tested annually. These include the majority of seedcane sources intended for planting. Additionally, in all mill supply areas large numbers of commercial fields are selected randomly for survey purposes.

Until recently, surveys of RSD in South Africa were based on the examination, by phase contrast microscopy (PCM), of xylem sap extracted from stalks collected in the field (Bailey and Fox, 1984). PCM is also used on a large scale in Zimbabwe. In early 1998, routine diagnosis in South Africa was changed to an evaporative binding-enzyme immunoassay (EB-EIA), based on a method developed in Australia (Croft *et al.*, 1994) and using a polyclonal antiserum to a local isolate of *Clavibacter xyli* subsp. *xyli* (*Cxx*).

RSD diagnosis in Zimbabwe in the period 1996-98 was based on PCM (Zvoutete, personal communication[1]).

[1] P Zvoutete, ZSAES, P Bag 7006, Chiredzi, Zimbabwe

Samples from Swaziland and Mozambique were examined by either PCM or immunofluorescence microscopy (IFM). Material from all the other countries was examined by IFM, again using a polyclonal antiserum to *Cxx*. For IFM, drops of xylem sap extracted from stalks are dried onto multi-celled slides. These are then delivered to SASEX for processing and examination.

In most cases, samples consisted of 20 stalks per field or section of field, chosen from weaker plants. This biased sampling was intended to increase the likelihood of detecting RSD, if present in the field. Larger, randomly collected samples of up to 100 stalks were used to determine the percentage of infected stalks in fields in South Africa. Estimates of the percentage of infected stalks per field were possible for several other countries, including Zimbabwe.

## Effect of RSD on yield

Numerous field experiments have been conducted by SASEX to determine the effects of RSD on cane and sugar yields. In the widely grown variety NCo376, which is the main variety in a number of African sugar industries, losses in sugar yield of 20-40% under average rainfed conditions and up to 20% under good irrigated conditions have been recorded. Some varieties, such as N17 and N14, are more intolerant than NCo376 and substantial losses have been recorded in most of the large number of varieties that have been tested (Bailey and Bechet, 1986; 1995). The results of two recent trials are shown in Figure 1.

Rainfall in southern and central Africa is mainly seasonal and often erratic. When infected crops are subjected to moisture stress from drought or inadequate irrigation, losses due to RSD can be dramatic. Reductions in sugar yield of 76% were recorded in variety NCo376 in the drought season of 1980-81 (Bailey and Bechet, 1986).

## Incidence of RSD and effects on production

*South Africa*

Surveys in the late 1970s showed that approximately 30% of fields in the southern, rainfed part of the South African industry contained some level of RSD. The incidence was greater in the northern production area, where the crop is grown under full irrigation, similar to conditions in most of the other industries discussed. In this northern area in the early 1980s, 62% of fields in Mpumalanga and 40-50% of fields in the Pongola mill area were infected (Bailey and Fox, 1984; Bailey and Tough, 1991).

In the last two decades in most parts of the South African industry, the mean number of fields in which RSD was detected has declined steadily. In 1997, RSD was detected in 21% of fields in the northern area and 6% of fields in the southern area, and the industry mean was 9%. This was the lowest ever recorded. The situation in the industry as a whole in 1997 is illustrated in Figure 2. Using EB-EIA, the mean number of fields infected in 1998 was estimated to be 12%.

In the southern, rainfed area (approximately 78% of total South African sugar production), intensive surveys have shown that the mean number of infected stalks in fields where RSD is present is low, approximately 1%. With this mean level of stalk infection, yield losses in most parts of the southern area are now thought to be negligible. The estimated mean number of stalks infected in the northern production area in 1997 was 7%, and the industry mean was 2%. In the South African industry as a whole, losses in 1979 were estimated to be approximately 5% of annual production (Bailey, 1979), but current losses are estimated to be equivalent to approximately 1% of production.

*Swaziland and Zimbabwe*

A number of RSD surveys based on IFM (1992-96) and

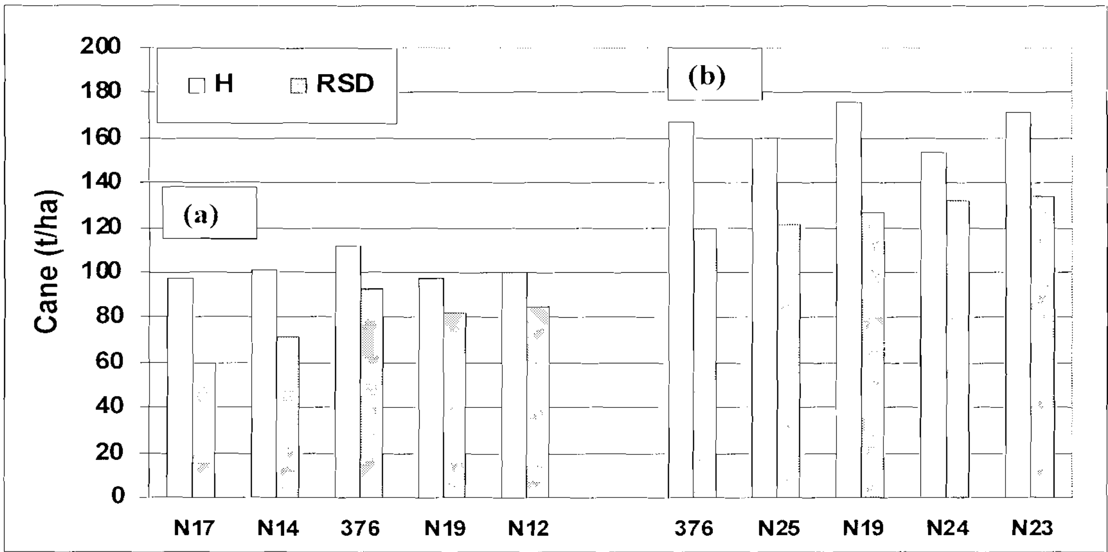


**Figure 1.** Effect of RSD on cane yield under (a) rainfed conditions at Mount Edgecombe (2R, 13,5 months, 1996); (b) irrigated conditions at Pongola (2R, 11,7 months, 1997; H = healthy seedcane, RSD = infected seedcane).

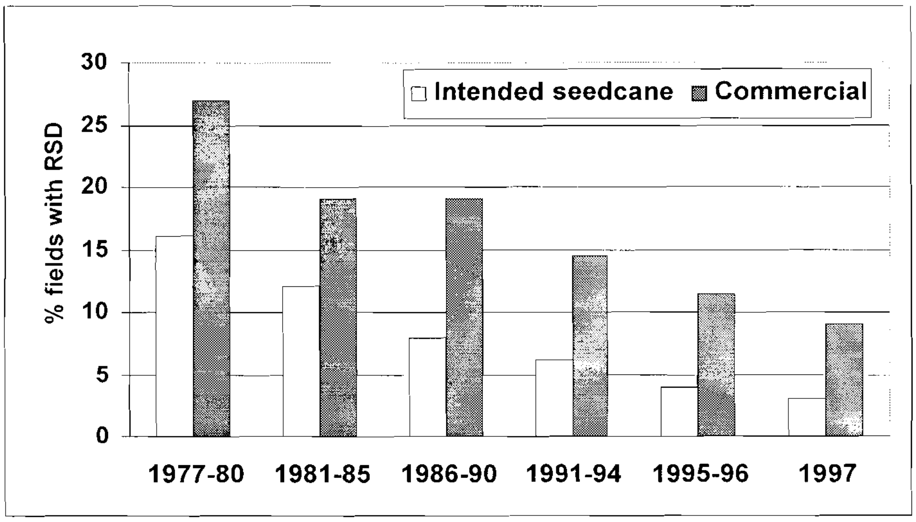


**Figure 2.** Mean incidence of RSD in intended seedcane sources and commercial fields in the South African sugar industry, 1977-1997 (% fields in which RSD was detected); any intended seedcane found to have RSD is not planted.

**Table 1. RSD incidence in Swaziland, 1992-1998 (% fields with RSD).**

| Year | No. fields tested | % fields with RSD |
|---|---|---|
| 1992 | 159 | 22 |
| 1993 | 291 | 15 |
| 1995 | 315 | 15 |
| 1996 | 247 | 30 |
| 1998 | 330 | 28 |

PCM (1998) have been conducted in Swaziland by SASEX. The mean number of commercial fields in which RSD was recorded ranged from 15 to 30% (Table 1), partly depending on the areas surveyed, but the two latest surveys gave similar results – means of approximately 30% infected fields (Table 1). Losses in production due to RSD are estimated to be approximately 4% of current production.

Until recently there had been little use of hot water treatment (HWT) in Zimbabwe for many years. After a devastating drought in the early 1990s the entire industry was re-established, starting in 1993. Unfortunately, the scarce seedcane stocks that were available had high levels of RSD and the replanting exercise served to spread RSD throughout the industry. Surveys of RSD incidence have been conducted by ZSAES since 1995 using PCM (Zvoutete, personal communication). Survey data from 1998 show that more than 80% of commercial cane fields were infected with RSD, and that approximately 60% of stalks were infected (Table 2). Reductions in yield in Zimbabwe due to RSD are estimated to be approximately 10% of annual production. The situation with regard to seedcane offers some encouragement, with 20% of intended sources being infected.

*Other countries*

Surveys in other countries have been less frequent, but it is likely that the data recorded are representative of the current situations. Extremely high levels of RSD were recorded at both Dwangwa and Nchalo in Malawi, at Nakambala in Zambia, at both Mumias and South Nyanza in Kenya, and at Kinyara in Uganda (Table 3). The results indicated that the majority of stalks in fields where RSD was identified were infected. In all these industries, the use of HWT to eliminate RSD from seedcane stocks has been sporadic. A feature of cane production in most of these industries is the relatively short break from cane before fields are replanted. Losses in yields in these industries probably amount to 10-20% of production.

Samples from 24 fields at Kilombero in Tanzania were

**Table 2. RSD incidence in Zimbabwe, 1996-98 (% fields infected and mean % stalks infected for all fields).**

| Year | No. fields tested | % fields with RSD | % stalks infected (all fields) |
|---|---|---|---|
| 1996 | 612 | 92 | 71 |
| 1997 | 1 372 | 64[1] | 51[1] |
| 1998 | 867 | 82 | 58 |

Note: [1] the apparent lower incidence in 1997 was due to many samples being fromseedcane and plant cane fields.

**Table 3. Incidence of RSD in Zambia, Malawi, Kenya and Uganda, 1993-1998 (% fields with RSD).**

| Country, area & year | No. fields tested | % fields with RSD |
|---|---|---|
| Zambia (Nakambala, ) | | |
| 1994 | 196 | 98 |
| 1996 + 1997 | 161 | 54 |
| 1998 | 50 | 46 |
| Malawi | | |
| Dwangwa (1993) | 36 | 67 |
| Nchalo (1995) | 62 | 74 |
| Kenya | | |
| South Nyanza (1993) | 196 | 96 |
| Mumias (1993) | 391 | 57 |
| Uganda | | |
| Kinyara (1997) | 50 | 82 |
| Tanzania | | |
| Kilombero (1998) | 24 | 100 |
| Mozambique | | |
| Mafambisse (1998) | 21 | 100 |

examined in 1998. All were found to be infected and the results indicated that most stalks were infected. Information on the status of RSD at Mafambisse in Mozambique was obtained by one of the authors (RAB) on a visit in 1991. Prior to that there had been no HWT on the estate for many years. On inspecting fields, the internal nodal symptoms of RSD were invariably found. Samples from a number of fields were brought to SASEX for confirmation by PCM. All were found to be infected and it was concluded that RSD was ubiquitous on the estate. These results were confirmed by further sampling in 1998. If the survey results are representative, it is estimated that reductions in production at both Kilombero and Mafambisse exceed 20%. In contrast, no RSD was found in stocks of N19 on a visit to Maragra estate in southern Mozambique in 1997. This estate is now being rehabilitated.

## Discussion and conclusions

Except for South Africa, RSD is estimated to be having a significant impact on sugar production in all the countries in southern and central Africa from which survey data are available.

Good progress has been made in reducing the incidence and economic significance of RSD in South Africa. The main factor that has contributed to the improved situation in all parts of the industry has been the widespread use of seedcane production schemes based on HWT. Most of the seedcane now planted is obtained from sources that have been tested for freedom from RSD. In all areas, there has been a close correlation between the RSD status in commercial fields and the quality of the seedcane planted. Further contributing factors include the improved attention given by growers to stubble destruction and the greater use of longer breaks from cane between plantings. It is recommended that fields have a break from cane of at least three months before replanting.

An important factor that contributed to RSD control in South Africa was the widespread publicity given to research results on the effect of RSD on yields and on the rate at which RSD can spread (Bailey and Tough, 1992). The diagnostic service has provided valuable information on the RSD situation at farm, area and industrial levels, as well as providing specific information to aid growers in making practical management decisions concerning seedcane sources and plough-out fields.

Sugarcane in Swaziland is produced mainly on large miller-cum-planter estates. As in most other industries in the region, the period between stubble destruction and replanting is usually short, sometimes only a few weeks. The industry has had a national seedcane scheme since the late 1970s, operated by the Swaziland Sugar Association. In this, elite seedcane is produced after HWT in an area remote from the main production areas and is used to establish commercial nurseries on the estates. This has been the main factor in achieving substantial control of RSD compared with most other industries in the region. Further progress in Swaziland below the current level of approximately 30% fields infected requires greater attention to stubble destruction. This will necessitate longer breaks between plantings than is currently practised.

In Zimbabwe, control of RSD has been identified as a high priority within the last three years, and a major drive to improve seedcane quality by greater use of HWT is now in progress on most estates. The diagnostic service provided by ZSAES will be a key factor in achieving success.

Major factors impeding an improvement in the RSD situations in the other industries mentioned are the current lack of HWT facilities and the lack of local services for large scale diagnosis. SASEX can provide further assistance with diagnosis but the development of local expertise would assist the situation.

In all the industries where RSD occurs at high levels, attention must be given to increasing the duration of the break between plantings to minimise the survival of infected volunteer regrowth. This recommendation is likely to meet some resistance until its value is supported by local survey and research results.

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