# THE EFFECT OF RATOON STUNTING DISEASE ON THE YIELD OF SOME SOUTH AFRICAN SUGARCANE VARIETIES UNDER IRRIGATED AND RAINFED CONDITIONS

RA BAILEY AND GR BECHET

*South African Sugar Association Experiment Station, Mount Edgecombe*

**Abstract**

The results of two field trials to determine the effect of ratoon stunting disease on the growth and yield of some widely grown and newly released sugarcane varieties are described. In the plant crop of a trial grown under full irrigation, the greatest reductions in yields of cane and sugar among six varieties, approximately 15%, occurred in N14 and NCo376. In the first ratoon, the greatest reductions in cane yield occurred in N14 (25%), N17 (19%), NCo376 (17%) and CP66/1043 (16%) and there were similar reductions in yields of sugar. The responses to infection recorded in the ratoon crop of the irrigated trial were probably under-estimated because of widespread infection detected in the control plots. In the plant crop of a trial with eight varieties grown under rainfed conditions and which received 80% of long term mean rainfall, the greatest reductions in cane yield occurred in varieties N17 (50%), N14 (32%) and NCo376 (22%). Significant losses were also recorded in N19 in both trials and in N21 in the rainfed trial. Variety N22 was tolerant of infection in both the irrigated and rainfed trials, and varieties N12 and N23 were tolerant in the rainfed trial. Yield reductions in both trials were mainly due to reduced stalk mass. There was little effect of infection on cane quality.

## Introduction

Ratoon stunting disease (RSD), caused by the bacterium *Clavibacter xyli* subsp *xyli* Davis *et al*, is well known to be an economically important disease of sugarcane in almost all countries where the crop is grown. It is also well known that varieties differ in response to infection by *C. xyli* subsp *xyli* and that the effects of infection differ according to growing conditions. In a previous trial conducted under average rainfed conditions at Mount Edgecombe on the North Coast of Natal, reductions in yield of recoverable sugar over a plant and two ratoon crops were 38% in NCo376 and N13 and 19% in N12. Several varieties, including N55/805 and N11, were much less severely affected (Bailey and Bechet, 1986). Much larger losses, up to 76% in NCo376, were recorded in another trial at Mount Edgecombe in which the crop suffered from drought stress (Anon., 1981).

There is little reliable information published on the effect of RSD on sugarcane grown under full irrigation in southern Africa. Rossler (1974) demonstrated a loss in recoverable sugar of 15% in a first ratoon crop of NCo376 receiving optimal irrigation. However, possibly because in that trial there was little effect on N55/805, subsequently found to be a relatively tolerant variety (Anon., 1981; Bailey and Bechet, 1986), and possibly because at the time the incidence of infection by *C. xyli* subsp *xyli* in the various treatments could not be accurately determined, the widespread impression was gained that RSD had only slight effects on irrigated cane in southern Africa.

In South Africa, the large scale diagnostic service provided by the SASA Experiment Station (SASEX) permits continual monitoring of the status of RSD in all areas. Progress towards reducing the impact of RSD on the South African industry and the current incidence of the disease are well documented. Since the late 1970s, the number of commercial cane fields infested by RSD has declined in most areas of the industry, and in 1993 a mean of 13% of commercial fields were found to be infested (Bailey and Fox, 1984; Bailey and Tough, 1991). However, high levels have persisted in some areas, most notably at Pongola where more than 40% of commercial fields have been infested for many years (Bailey *et al.*, 1994).

In the South African sugar industry as a whole, the percentage of fields infested with RSD increases progressively with ratooning, and approximately 20% of second ratoon and older fields are infested. In the Pongola area, more than 50% of fields older than second ratoon are infested, often severely (*Bailey, unpublished data). Therefore, production at the field, farm and regional level is often seriously affected. Losses in the Pongola area may amount to 10% of production annually, and losses in the South African sugar industry overall were recently estimated to amount to 2% of annual production (Bailey *et al.*, 1994).

The improved RSD situation in most parts of the South African industry has followed an increase in the application of control measures by growers, partly in response to the publicity given to the widespread occurrence of the disease and to the magnitude of its effects on the productivity of widely grown varieties. An important aspect of the SASEX research programme, therefore, is to determine the effect of RSD infection on commercial varieties under different growing conditions.

The two field trials reported in this paper, one under irrigated and one under rainfed conditions, included some old varieties tested previously under rainfed conditions and also a number of more recently released, widely grown varieties tested for the first time. The irrigated trial is the first conducted under such conditions in the South African sugar industry in which the extent of RSD infection in the different treatments was accurately determined.

## Materials and Methods

### *Irrigated trial*

This trial with six varieties was planted on a red sandy clay loam of the Hutton-Makatini form (30% clay) at the SASA's Pongola field station in northern Natal in October 1991. This is a warm, semi-arid area (LTM rainfall 660 mm/annum) and the crop is grown under fully irrigated conditions. Potential production is high. The plant crop was harvested in September 1992 at an age of 11,5 months and the first ratoon crop in July 1993, 10,1 months later.

The plant crop received 408 mm rainfall and 793 mm water applied by overhead sprinklers, giving a total of 1 201 mm water. The first ratoon received 561 mm rainfall and 610 mm irrigation, giving a total of 1 171 mm.

* RA Bailey, Head Pathology Dept, SASEX, Mt Edgecombe

Each variety was represented by initially healthy (control) and diseased plots in a split-plot design with varieties in the main plots and diseased or healthy seedcane in the subplots. There were three replications. Each subplot consisted of four rows, 8,0 m long and at a spacing of 1,4 m. Analysis of the results was based on data from the two centre rows of each plot.

The seedcane of all the varieties was obtained from special propagation plots at Mount Edgecombe. These had been established with seedcane obtained from healthy nurseries that was then either subjected to hot water treatment for 2 h at 50°C or inoculated with *C. xyli* subsp *xyli* using the standard pressure cup method with juice from infected stalks immediately before planting. Stalks plucked from the plant crop of these propagation plots were used to establish the trial.

When the plant crop was harvested, precautions were taken to prevent the spread of RSD to the initially healthy plots. The extent of RSD infection in each treatment in the first ratoon crop was assessed immediately before harvest. Five stalks were selected at random from each of the four rows in each plot, i.e. a total of 60 stalks for each of the 12 treatments. The xylem sap was expressed from one internode of each of the stalks sampled and examined separately by phase contrast microscopy for RSD bacteria. The severity of infection was scored on a range from 0 (nil) to 4 (very severe) according to the abundance of bacteria observed.

*Rainfed trial*

This trial with eight varieties was planted on a grey sandy loam of the Longlands form (25% clay) at Mount Edgecombe in October 1992. The seedcane was obtained from the first ratoon crop of the propagation plots used for the irrigated trial. The plant crop was harvested in May 1994 at an age of 19,2 months.

This trial also had a split-plot design with varieties in the main plots, and had four replications. Each subplot consisted of four rows 6,5 m long (net plot two centre rows) at a spacing of 1,2 m.

A total of 1 395 mm rain fell during the trial period. This was 80% of the long term mean (LTM). Rainfall was particularly low during the first six and last five months, i.e. the summer of the 1992-93 season and the late summer and autumn of 1993-94, when 61% and 65% of the LTM rainfall respectively were recorded.

## Results

*Irrigated trial*

Seedcane in all the plots germinated well. In the first ratoon crop, infection was detected in all the stalks collected from the plots that had been planted with infected seedcane. The severity of infection in the diseased plots was uniform among the different varieties (mean score 3,1, range 2,7-3,3).

Despite the precautions taken to prevent the spread of RSD from the diseased to the initially healthy plots when the plant crop was harvested, widespread infection was detected in the first ratoon crop in the initially healthy plots. In the first ratoon, infection was detected in a mean of 56% of stalks in the plots that had been planted with healthy seedcane, ranging from 25% in N22 to 88% in CP66/1043 and 92% in N14 (Table 1). The severity of infection in the initially healthy plots differed widely among the varieties (mean for all varieties 1,3, range 0,6-2,6) and was particularly high in N14, in which the mean severity was assessed as moderate to severe.

Yields of cane and estimated recoverable sugar (ers) were high in the initially healthy plots in both the plant and first ratoon crops, reflecting the good growing conditions (Table 2). The highest yields of cane and recoverable sugar in both

**Table 1**

**Percent stalks with *C. xyli* subsp *xyli* and rating of severity of infection in six varieties in first ratoon, full irrigation (H = initially healthy; RSD = infected. 0 = nil; 1 = slight; 2 = moderate; 3 = severe and 4 = very severe).**

| Variety | % stalks infected | | Severity of infection (a) all stalks, (b) infected stalks | | |
|---|---|---|---|---|---|
| | H | RSD | H | | RSD |
| | | | (a) | (b) | |
| N14 | 92 | 100 | 2,6 | 2,8 | 3,1 |
| N17 | 48 | 100 | 1,2 | 2,4 | 3,2 |
| NCo376 | 45 | 100 | 1,0 | 2,3 | 3,2 |
| CP66/1043 | 88 | 100 | 1,5 | 2,4 | 3,3 |
| N19 | 37 | 100 | 0,8 | 2,3 | 2,7 |
| N22 | 25 | 100 | 0,6 | 2,2 | 2,8 |
| Mean | 56 | 100 | 1,3 | 2,4 | 3,1 |

**Table 2**

**Effect of RSD on the yields of cane and recoverable sugar of six varieties grown under full irrigation (plant cane, 11 months, first ratoon 10,1 months; H = initially healthy; RSD = infected;* = significant at 95% probability).**

| Variety | Cane (t/ha) | | | | Recoverable sugar (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | Plant crop | | First ratoon | | Plant crop | | First ratoon | |
| | H | RSD | H | RSD | H | RSD | H | RSD |
| N14 | 144 | 123 (−15%)* | 149 | 112 (-25%)* | 17,2 | 14,6 (−15%) | 18,8 | 13,5 (−28%)* |
| N17 | 101 | 93 (−8%) | 125 | 101 (−19%)* | 11,9 | 11,5 (− 3%) | 14,8 | 12,4 (−16%) |
| NCo376 | 107 | 92 (−14%)* | 117 | 97 (−17%)* | 12,8 | 10,8 (−16%) | 12,3 | 10,9 (−11%) |
| CP66/1043 | 80 | 74 (−8%) | 92 | 77 (−16%) | 11,7 | 11,0 (−6%) | 12,5 | 10,2 (−18%) |
| N19 | 117 | 102 (−13%)* | 125 | 110 (−12%) | 14,5 | 12,8 (−12%) | 14,9 | 12,9 (−13%) |
| N22 | 107 | 109 (+ 2%) | 124 | 115 (−7%) | 13,9 | 16,9 (+22%) | 16,0 | 14,7 (− 8%) |
| LSD (P=0,05) | 15 | | 19 | | 3,5 | | 2,5 | |
| Means | 109 | 99 (−9%)* | 122 | 102 (−16%)* | 13,7 | 13,0 (−5%)* | 14,9 | 12,4 (−17%)* |
| LSD (P=0,05) | 6 | | 8 | | 0,7 | | 1,0 | |

crops were recorded in N14 (150 tons cane and 17,9 tons sugar/ha/annum in the plant crop and 177 tons cane and 22,3 tons sugar/ha/annum in first ratoon).

Compared with the initially healthy plots, the diseased plots showed significant reductions in the mean yields of cane of 9% in the plant crop and 16% in first ratoon (Table 2). In the plant crop, the greatest reductions in cane yield occurred in N14 (−15%), NCo376 (−14%) and N19 (−13%). In the first ratoon, the greatest reduction was recorded in N14 (−25%) and there were substantial reductions in most varieties. Cane yield was least affected in N22 in both crops.

In the plant crop a significant increase in cane quality (ers % cane) was detected in N22 following RSD infection, but differences in the other varieties were slight. In the ratoon crop, responses in ers % cane following RSD infection were variable and were not significant (P = 0,05) in any variety. The mean response of the varieties to infection in terms of cane quality was not significant in either crop (Table 3).

With the exception of N22 in the plant crop, RSD infection had a negative effect on the yields of recoverable sugar of all the varieties in both crops (Table 2). The effects on yields of sugar of the different varieties generally reflected those on yields of cane. The mean reductions in yield of recoverable sugar for all varieties in both crops, −5% and −17% respectively, were both significant (P = 0,05).

**Table 3**

**Effect of RSD on cane quality (ers % cane) of six varieties grown under irrigation (plant cane 11,5 months, first ratoon 10,1 months; H = initially healthy; RSD = infected; * = significant at 95% probability)**

| Variety | Ers % cane | | | |
|---|---|---|---|---|
| | Plant crop | | First ratoon | |
| | H | RSD | H | RSD |
| N14 | 12,1 | 11,9 | 12,5 | 11,8 |
| N17 | 11,8 | 12,1 | 11,9 | 12,3 |
| NCo376 | 11,8 | 11,8 | 10,4 | 11,5 |
| CP66/1043 | 14,8 | 14,9 | 13,8 | 13,2 |
| N19 | 14,0 | 14,3 | 11,8 | 11,6 |
| N22 | 12,9 | 15,2* | 12,8 | 12,8 |
| LSD (P = 0,05) | 1,4 | | 1,4 | |
| Means | 12,7 | 13,1 | 12,2 | 12,2 |
| LSD (P=0,05) | 0,6 | | 0,6 | |

In the plant crop, stalk populations were significantly reduced in the infected plots of N14, N17 and NCo376 and the mean reduction among all varieties (−6%) was significant (Table 4). In the first ratoon crop, although there were slightly fewer stalks in four of the six varieties, the mean reduction (−4%) was not significant. The mean mass of individual stalks was reduced by 4% in the plant crop and 13% in the first ratoon (Table 4). In the plant crop, reductions in stalk population and stalk mass both contributed to the reduction in cane yield, whereas in the first ratoon crop the main factor contributing to reduction in yield was reduced stalk mass.

*Rainfed trial*

Good germination was recorded in all plots. Microscopic examination of samples from guard rows showed that almost all stalks in the diseased plots of all varieties were infected and that the healthy plots remained so for the duration of the plant crop.

Considering the low rainfall, cane yields in the healthy plots were good, with a mean for all varieties of 113 t/ha (70 t/ha/annum). The highest cane yield in the healthy plots was 151 t/ha for N21 (93 t/ha/annum), followed by more than 130 t/ha for N17 and NCo376 (80 t/ha/annum). The highest yields of recoverable sugar in the healthy plots, more than 15,5 t/ha, were recorded for N21 and N19, the latter due to its relatively good cane quality when the trial was harvested early in the milling season (Table 5).

There was a wide range of varietal responses to RSD (Tables 5 and 6). In terms of cane yield in the plant crop, N17 was by far the most severely affected (−50%), followed by N14 (−32%), NCo376 (−22%) and N21 (−17%). In the plant crop, RSD had negligible, if any, effect on the cane yields of N12, N22 and N23 (Table 5).

RSD infection had no overall effect on cane quality (ers % cane) although a significant reduction was recorded in N19. Therefore, the effects of infection on yield of sugar largely reflected those on cane yield (Table 5).

Infection with RSD significantly reduced the stalk population of N17 but had a much smaller effect on the stalk populations of the other varieties (Table 6). There were sig-

**Table 4**

**Effect of RSD on stalk population and stalk mass of six varieties grown under full irrigation (plant cane, 11,5 months, first ratoon 10,1 months; H = initially healthy; RSD = infected; * = significant at 95% probability)**

| Variety | Stalks/ha × $10^{-3}$ | | | | Mean stalk mass (kg) | | | |
|---|---|---|---|---|---|---|---|---|
| | Plant crop | | First ratoon | | Plant crop | | First ratoon | |
| | H | RSD | H | RSD | H | RSD | H | RSD |
| N14 | 144 | 139* | 182 | 187 | 1,00 | 0,88 | 0,82 | 0,60 |
| N17 | 134 | 118* | 207 | 194 | 0,75 | 0,79 | 0,60 | 0,52 |
| NCo376 | 147 | 118* | 203 | 188 | 0,73 | 0,78 | 0,58 | 0,52 |
| CP66/1043 | 93 | 100 | 115 | 105 | 0,86 | 0,74 | 0,80 | 0,73 |
| N19 | 128 | 121 | 168 | 155 | 0,91 | 0,84 | 0,74 | 0,71 |
| N22 | 141 | 140 | 189 | 189 | 0,76 | 0,78 | 0,66 | 0,61 |
| LSD (P=0,05) | 17 | | 24 | | - | | - | |
| Means | 131 | 123 (−6%)* | 177 | 170 (−4%) | 0,83 | 0,80 (−4%) | 0,69 | 0,60 (−13%) |
| LSD (P=0,05) | 7 | | 10 | | - | | - | |

Table 5

**Effect of RSD on the yields of cane and recoverable sugar and on cane quality of eight varieties grown under rainfed conditions (plant cane 19,5 months; * = significant at 95% probability)**

| Variety | Yield (t/ha) and % response | | | | Ers % cane | |
|---|---|---|---|---|---|---|
| | Cane | | Recoverable sugar | | | |
| | H | RSD | H | RSD | H | RSD |
| N17 | 135 | 68 (−50%)* | 13,7 | 6,9 (−49%)* | 10,2 | 10,0 |
| N14 | 121 | 82 (−32%)* | 11,3 | 7,0 (−38%)* | 9,4 | 8,5 |
| NCo376 | 131 | 102 (−22%)* | 13,5 | 10,8 (−20%)* | 10,3 | 10,5 |
| N21 | 151 | 124 (−17%)* | 15,8 | 14,6 (−8%) | 10,5 | 11,7 |
| N19 | 123 | 109 (−11%) | 15,6 | 12,3 (−21%)* | 12,9 | 11,3* |
| N23 | 113 | 105 (−7%) | 12,1 | 10,7 (−12%) | 10,6 | 10,3 |
| N12 | 122 | 119 (−2%) | 12,8 | 13,1 (+2%) | 10,4 | 10,9 |
| N22 | 100 | 103 (+2%) | 11,5 | 11,6 (+1%) | 11,5 | 11,3 |
| LSD (P=0,05) | 22 | | 2,6 | | 1,5 | |
| Means | 113 | 102 (−18%)* | 13,3 | 10,9 (−18%)* | 10,7 | 10,6 |
| LSD (P=0,05) | 8 | | 0,9 | | 0,5 | |

Table 6

**Effect of RSD on some components of yield of eight varieties grown under rainfed conditions (plant cane 19,5 months; H = healthy; * = significant at 95% probability)**

| Variety | Yield component | | | | | |
|---|---|---|---|---|---|---|
| | Stalks/ha × $10^{-3}$ | | Stalk length (cm) | | Mean stalk mass (kg) | |
| | H | RSD | H | RSD | H | RSD |
| N17 | 120 | 85* | 208 | 178* | 1,13 | 0,80 (−29%) |
| N14 | 105 | 101 | 192 | 154* | 1,15 | 0,81 (−30%) |
| NCo376 | 135 | 144 | 170 | 150* | 0,97 | 0,71 (−27%) |
| N21 | 112 | 103 | 227 | 221 | 1,34 | 1,20 (−10%) |
| N19 | 100 | 101 | 201 | 190 | 1,23 | 1,08 (−12%) |
| N23 | 121 | 119 | 185 | 186 | 1,00 | 0,88 (−12%) |
| N12 | 117 | 131 | 180 | 178 | 1,04 | 0,91 (−13%) |
| N22 | 115 | 119 | 149 | 149 | 0,87 | 0,87 |
| LSD (P=0,05) | 17 | | 17 | | - | |
| Means | 116 | 113 | 189 | 176* | 1,08 | 0,90 (−17%) |
| LSD (P=0,05) | 6 | | 6 | | - | |

nificant reductions in stalk length in N14, N17 and NCo376, which were the three most severely affected varieties in terms of cane yield. The mean mass of individual stalks was reduced in all varieties except N22 (Table 6). Stalk mass was reduced by between 27 and 30% in the three most severely affected varieties and reductions in this component were most closely related to the effects of RSD on the yield of cane and recoverable sugar.

## Discussion

The substantial reductions in yield in most of the varieties in both the irrigated and rainfed trials were mainly due to the infected cane having shorter, thinner stalks. Stalk populations were slightly but consistently reduced. There was no general effect of infection on sucrose content in either trial. These reactions of infected cane are consistent with those reported from the previous trial conducted at Mount Edgecombe (Bailey and Bechet, 1986) and reports from other countries (Gillaspie and Teakle, 1989).

The trial at Pongola demonstrated that RSD can cause substantial reductions in the yield of well managed crops grown under full irrigation. The results also demonstrated that a number of the varieties grown in the irrigated cane production areas of southern Africa (N14, N17, CP66/1043) are relatively intolerant of infection, while N19 also suffered substantial losses. The results obtained with NCo376 in the irrigated trial are in close agreement with those from a previous trial conducted under irrigated conditions at Pongola from 1987-92 (*Bailey and Bechet, unpublished data). In that trial there were consistent reductions in cane yield from the plant to the fourth ratoon crop in varieties NCo376 and N12, with mean reductions of approximately 17% and 11% respectively (Figure 1).

The extent to which the effects of RSD on yield in the irrigated trial were under-estimated because of the high level of infection found in the control plots is uncertain. It seems likely that the control plots were largely disease-free in the

* RA Bailey, GR Bechet, Pathology Dept, SASEX, Mt Edgecombe

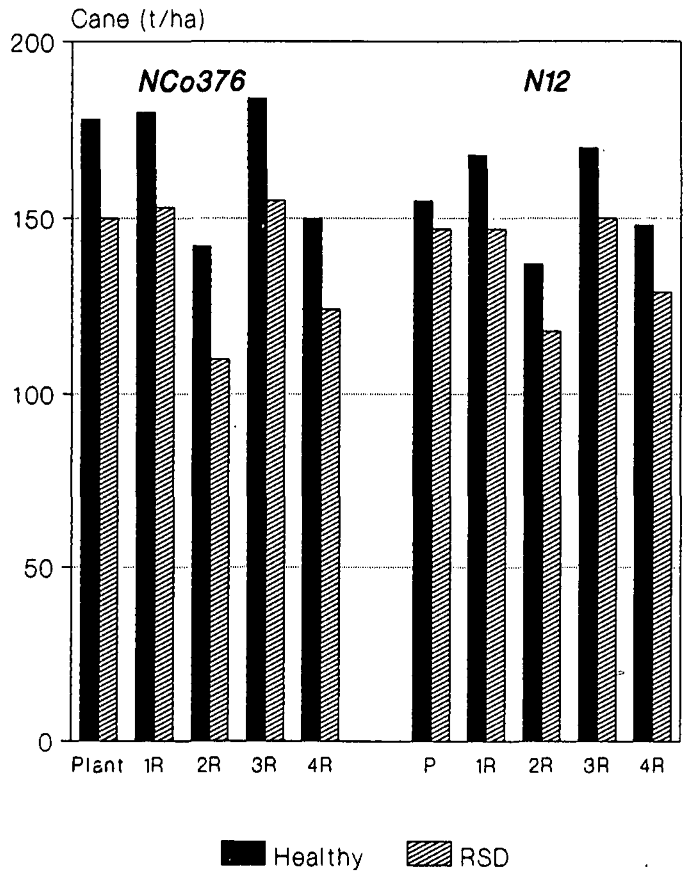


**FIGURE 1** Effect of RSD on the yield of cane of NCo376 and N12 grown under full irrigation at Pongola and harvested annually, 1987-88 to 1991-92.

plant crop, in which case the results from that crop probably provide a good estimate of the effect of RSD in plant cane grown under irrigation, if infected seedcane is used. In the first ratoon crop, the degree of under-estimation must have differed among the varieties. However, it is clear that the effects on N14 and CP66/1043 have been seriously under-estimated, and on N17 and NCo376 to a lesser extent.

Even if any under-estimation in the ratoon crop is discounted, the recorded loss of 28% in the sugar yield of N14 is substantial, and a cause for concern considering the popularity of this variety in irrigated areas and the frequency with which it is found to be infected with RSD on cane farms.

The different levels of infection recorded in the control plots in the ratoon crop of the irrigated trial provide an indication of the relative resistance of the varieties to infection. This is supported by the results of wide-scale surveys of the occurrence of RSD in commercial crops, which consistently show that RSD is most common in fields of N14 compared with other varieties (*Bailey, unpublished data). It is noteworthy that RSD had the least effect on yield in N22 and that the control plots of this variety had the lowest incidence of infection.

There was good agreement in the relative reactions of the different varieties in the two trials. Varieties N17, N14 and NCo376 were the most severely infected, N22 the least affected and N19 had an intermediate reaction in both trials.

* RA Bailey, Head Pathology Dept, SASEX, Mt Edgecombe

Yields of CP66/1043 were substantially reduced in the irrigated trial and those of N21 in the rainfed trial.

The results from the plant crop of the rainfed trial indicated that N12 was relatively tolerant of infection (reduction in cane yield of 2%). However, this compares with reductions of 9% in the plant crop and 20% in the first and second ratoon crops of a previous trial conducted under rainfed conditions. In that trial there was a loss of 45% in the first and second ratoon crops of NCo376 (Bailey and Bechet, 1986). In a previous trial under irrigated conditions, reductions in cane yield in N12 amounted to 11% from the plant to fourth ratoon crops (Figure 1). These various results indicate that N12 is much less seriously affected than NCo376 by RSD, but can nevertheless suffer appreciable losses.

The reductions in yield of many of the varieties in the plant crop of the rainfed trial were substantial, despite the fact that the effects of RSD on the growth and yield of sugarcane are invariably greater in ratoon crops.

The results from the plant crop of the rainfed trial therefore confirm the severe effect of RSD when the crop suffers from drought stress. Results from ratoon crops of the rainfed trial will provide further information on the reactions of the varieties under test to RSD under rainfed conditions.

## Conclusions

RSD caused substantial reductions in the cane and sugar yields of varieties N14, N17, NCo376, CP66/1043 and N19 under fully irrigated conditions. Where the disease is common in irrigated areas, it must therefore have serious economic consequences. Varieties N17, N14 and NCo376 were severely affected by RSD under conditions of moderate drought stress. Variety N22 was tolerant of RSD infection under both irrigated and rainfed conditions. Reductions in yield because of RSD infection were mainly due to infected cane having shorter, thinner stalks. There was no general effect of RSD infection on cane quality.

## Acknowledgements

G Chinnasamy, D Subramoney and SA McFarlane provided valuable assistance. Their contributions are gratefully acknowledged.

## REFERENCES

Anon. (1981). RSD and drought. *Ann Rep S Afr Sug Ass Exp Stn* 1980-81: 70.

Bailey, RA and Bechet, GR (1986). Effect of ratoon stunting disease on the yield and components of yield of sugarcane under rainfed conditions. *Proc S Afr Sug Technol Ass* 60: 143-147.

Bailey, RA and Fox, PH (1984). A large-scale diagnostic service for ratoon stunting disease of sugarcane. *Proc S Afr Sug Technol Ass* 58: 204-209.

Bailey, RA and Tough, SA (1991). The current distribution of ratoon stunting disease in the South African sugar industry. *Proc S Afr Sug Technol Ass* 65: 25-29.

Bailey, RA, Bechet, GR and Tucker, AB (1994). Progress towards disease control in the South African sugar industry. *Proc S Afr Sug Technol Ass* 68: 3-7.

Gillaspie, AG and Teakle, DS (1989). Ratoon stunting disease. In: *Sugarcane diseases of the world.* Vol 1 (revised). Elsevier, Amsterdam. pp 59-80.

Rossler, LA (1974). The effects of ratoon stunting disease on three varieties under different irrigation regimes. *Proc int Soc Sug Cane Technol* 15: 250-257.