FURTHER EVIDENCE OF THE EFFECTS OF RATOON STUNTING DISEASE ON PRODUCTION UNDER IRRIGATED AND RAINFED CONDITIONS

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Abstract

In a field experiment under rainfed conditions, reductions in cane yield over three crops due to infection by ratoon stunting disease (RSD) ranged from 41% to 19 % respectively in varieties N17, N14, N21, NCo376 and N19. Losses in N12 were 10%, and in N23 and N22 were 7% and 1%. In a similar trial conducted under irrigation, the greatest reductions in cane yield over two crops were 32% in variety N25, 29% in NCo376, 22% in N24 and 21% in N19. The effects of RSD on yield of recoverable sucrose were similar to those on cane yields. Reductions in yield were mainly due to reductions in stalk mass.

Based on field experiments conducted since 1980 to determine the effect of RSD on growth and yield, currently popular and new South African released varieties are ranked as follows in terms of the effect of RSD on production: intolerant, N17, N14, NCo376, N24, N25; intermediate, N24, N19, N12, N23; relatively tolerant, N22. That substantial losses from RSD can occur in most varieties under irrigated as well as rainfed conditions demonstrates the importance of precautionary action by growers to prevent the introduction and spread of RSD in cane plantings.

Introduction

Ratoon stunting disease (RSD), caused by the bacterium *Clavibacter xyli* subsp *xyli* Davis *et al.(Cxx)*, is well known to be an economically important disease of sugarcane in most countries where the crop is grown. It is also well known that varieties differ in response to infection by *Cxx* and that the effects of infection can vary with growing conditions. Generally, losses due to RSD are relatively greater when the crop suffers from stress.

Until recently, there was little reliable information published on the effect of RSD on sugarcane grown under full irrigation in southern Africa. However, the results of an irrigated trial conducted at Pongola from 1991 to 1993 demonstrated yield reductions as great as 25% in N14 and 17% in NCo376 (Bailey and Bechet, 1995). These results confirmed that RSD can cause substantial yield reductions in irrigated cane, even under good growing conditions.

The continually improving 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 production. An important aspect of the SASEX research programme therefore is to determine the effect of RSD infection on popular and new commercial varieties under different growing conditions.

The results of two field trials are reported in this paper, one under rainfed and one under irrigated conditions, include some varieties from previous similar experiments and some varieties tested for reaction to RSD for the first time. The results from the plant crop of the rainfed trial were published in 1995 (Bailey and Bechet, 1995). This paper contains results from the first and second ratoon crops. The results from a further trial conducted under irrigated conditions are also presented.

Experimental procedures

The seedcane of all the varieties for both trials 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 *Cxx* using the standard pressure cup method with juice from infected stalks immediately before planting. Stalks plucked from these propagation plots were used to establish the trials.

When the trials were harvested, precautions were taken to prevent the spread of RSD to the healthy plots. Stalks were sampled from the guard rows of the trials in all crops and checked by phase contrast microscopy for the presence of *Cxx*. These tests confirmed that *Cxx* did not spread into the plots that had been planted with healthy seedcane and that the diseased plots were uniformly infected.

Rainfed trial

This trial with eight varieties was planted on a grey sandy loam soil (approximately 25% clay) at Mount Edgecombe on the North Coast of KwaZulu-Natal 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. The first and second ratoon crops were harvested in September 1995 and October 1996 after 15,4 and 13,3 months respectively.

This trial 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.

The plant crop was affected by the final stages of the 1991-94 drought and received only 80% of long term mean rainfall (LTM). However, rainfall during the first and second ratoon crops amounted to 93% and 123% LTM respectively.

Irrigated trial

This trial with six varieties was planted on a red sandy clay loam soil form (approximately 30% clay) at the SASA's Pongola field station in northern KwaZulu-Natal in November 1994. This is a warm, semi-arid area (LTM rainfall 660 mm/annum) and the crop is grown under full irrigation. Potential production is high. The plant crop and first ratoon crops were harvested in September 1995 and September 1996 at crop ages of 9,7 and 11,9 months respectively.

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 four replications. Each subplot consisted of four rows, 7,0 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 plant crop was affected somewhat by restrictions in irrigation supply and accordingly was subjected to some stress. However, the first ratoon crop received close to standard irrigation for the area.

Results

The seedcane of all varieties in both experiments germinated well. Tests conducted on samples from the guard rows showed that RSD did not spread into any of the healthy plots in either experiment.

Rainfed trial

The growth of the plant crop of this experiment was affected by the low rainfall from 1992 to 1994 but conditions improved for the first and second ratoon crops. This is reflected in the mean yields of the healthy plots improving from 79 t/ha/annum in the plant crop to 87 and 92 t/ha/annum respectively in the first and second ratoon crops.

RSD caused a reduction in cane yield in all varieties in all three crops, but the varieties differed widely in the magnitude of the reduction. N17 was the most severely affected variety, its yield being reduced by 42% over the three crops, followed by N14 (–31%), N21 (–24%), NCo376 (–21%) and N19 (–19%). There was little effect of RSD in the plant crop of N12, but the reductions in the subsequent two crops were significant and there was a overall loss of 10% in this variety over the three crops. There was little effect of RSD on the cane yields of varieties N22 and N23 over the duration of the experiment, with N22 appearing to be particularly tolerant (Table 1).

Whereas the effects of RSD on growth and yield usually increase with ratooning, in this experiment the overall effects were similar in the three crops (mean reductions in cane yield of all varieties of –20, –20 and –19% respectively). This can be explained by the improvement in conditions from the plant crop through to the second ratoon (Table 1).

The effects of RSD on the yields of recoverable sugar of the different varieties (Table 2) were broadly similar to those on cane yield, since there was no overall consistent or significant effect of infection on cane quality (mean response of +0,8% across all varieties over three crops; Table 3).

There were slight but consistent reductions in stalk populations due to RSD and overall the mean stalk population of all eight varieties over all three crops was reduced by 5%. Mean stalk length was reduced significantly in all three crops and by a mean of –9% across all varieties and crops (Table 4).

Irrigated trial

Restrictions in the supply of water for irrigation adversely affected growth in the plant crop, and the mean cane yield in

Table 1
Yield of cane (t/ha) in healthy (H) and RSD infected plots of eight varieties under rainfed conditions (plant crop 19,5, first ratoon 15,4, second ratoon 13,3 months; *significant at 95% probability).

Variety	Plant crop		First ratoon		Second ratoon		P+1R+2R		% loss P-2R
	H	RSD	H	RSD	H	RSD	H	RSD	
N17	135	68*	107	68*	97	60*	339	196	–42
N14	129	82*	106	78*	101	71*	336	231	–31
N21	161	124*	116	90*	110	82*	387	296	–24
NCo376	131	102*	125	95*	112	93*	368	290	–21
N19	133	109*	109	83*	97	82*	339	274	–19
N12	122	119	112	96*	100	85*	334	300	–10
N23	113	105	119	108	102	98	334	311	–7
N22	101	103	94	92	96	90	287	285	–1
LSD (5%P)	21		13		12		–	–	–
Means	128	102* (–20%)	111	89* (–20%)	102	83* (–19%)	341	273	–20%
LSD (5%P)	7		4		4		–	–	–

Table 2
Yield of recoverable sugar (t/ha) in healthy (H) and RSD infected plots of eight varieties under rainfed conditions (plant crop 19,5, first ratoon 15,4, second ratoon 13,3 months; *significant at 95% probability).

Variety	Plant crop		First ratoon		Second ratoon		P+1R+2R		% loss P-2R
	H	RSD	H	RSD	H	RSD	H	RSD	
N17	13,7	6,9*	14,1	9,2*	13,1	8,0*	40,9	24,2	–41
N14	11,3	7,0*	13,5	19,3*	13,2	9,1*	38,0	26,4	–31
N21	16,7	14,6	15,8	12,9*	16,3	11,8*	48,8	39,3	–19
NCo376	13,5	10,8	16,7	12,6*	15,0	12,9*	45,2	36,3	–20
N19	16,0	12,3*	15,9	12,0*	13,7	12,1	45,6	36,4	–20
N12	12,8	13,1	13,7	12,5	12,9	10,5*	39,4	36,1	–8
N23	12,1	10,7	15,8	14,7	13,9	13,4	41,8	38,8	–7
N22	11,3	11,6	12,8	12,9	13,5	12,6	37,6	37,1	–1
LSD (5%P)	2,8		1,9		2,0		–	–	–
Means	13,4	10,9* (–19%)	14,8	12,1* (–18%)	14,0	11,3* (–19%)	42,2	34,3	–19%
LSD (5%P)	1,0		0,7		0,7		–	–	–

Table 3
Effect of RSD on cane quality (ers % cane) of eight varieties under rainfed conditions (difference between healthy and infected; *significant at 95% probability).

Variety	Plant crop	First ratoon	Second ratoon	Mean
N17	+0,22	+0,25	–0,31	+0,05
N14	–0,30	+0,48	–0,35	–0,06
N21	+1,39	+0,64	–0,49	+0,51
NCo376	+0,24	–0,11	+0,53	+0,22
N19	–0,80	+0,02	+0,54	–0,08
N12	+1,39	+0,67	–0,44	+0,54
N23	–0,38	+0,33	–0,01	–0,02
N22	–0,01	+0,21	+0,04	+0,08
LSD (5%P)	1,44	0,93	0,89	–
Means	+0,05 (+0,5%)	+0,31 (+2,3%)	–0,06 (–0,4%)	+0,16 (+0,8%)
LSD (5%P)	0,51	0,33	0,31	–

Table 4
Effect of RSD on stalk population and stalk length of eight varieties under rainfed conditions (*significant at 95% probability).

Crop stage	Plant crop		First ratoon		Second ratoon		Means	
Health status	H	RSD	H	RSD	H	RSD	H	RSD
Stalks/ha ($x10^{-3}$)	117	113 (–3%)	123	112* (–9%)	118	114 (–3%)	119	113 (–5%)
LSD (5%P)	6		4		9		–	
Stalk length (m)	1,92	1,76* (–8%)	2,02	1,86* (–9%)	1,60	1,46* (–9%)	1,85	1,69 (–9%)
LSD (5%P)	0,06		0,05		0,06		–	

the healthy plots, equivalent to 108 t/ha/annum, was much lower than expected at this trial site. Variety N14 was particularly affected by the stress and its yield in the plant crop was only 90t/ha/annum. Conditions improved in the first ratoon and the mean cane yield in the healthy plots of N14 increased to 128 t/ha/annum.

RSD caused reductions in cane yield in all varieties in both crops. In the plant crop, RSD reduced the cane yields of N25, NCo376 and N24 significantly and by more than 20%, and the mean reduction across all six varieties was 18%. The mean reduction in cane yield across all varieties in the first ratoon increased to 27% and the greatest losses occurred in varieties N25 and NCo376 (both –37%), N19 (–29%) and N24 (–22%). However, reduction in cane yield of N14, –11%, was again less than expected from results of other experiments (Table 5).

The mean yields of recoverable sucrose of all varieties in both crops were reduced significantly, by 10% and 25% respectively, and in the ratoon crop the reductions were significant in all varieties except N14 (Table 6). In the plant crop, mean ers % cane was increased significantly by RSD but there was no such effect in the first ratoon crop (Table 7).

RSD caused a slight reduction in stalk population in four of the six varieties in the plant crop and the mean population was reduced by 3%. However, in the first ratoon crop the stalk population was reduced in all varieties and the mean was reduced by 19% (Table 8).

Discussion and Conclusions

The results of these latest experiments on the effects of RSD on the growth and yield of different varieties have broadly confirmed the results of previous experiments (Bailey and Bechet,

Table 5
Yield of cane (t/ha) in healthy (H) and RSD infected plots of six varieties under rainfed conditions (plant crop 9,7, first ratoon 11,9 months; *significant at 95% probability).

Variety	Plant crop		First ratoon		P+1R		% loss P+1R
	H	RSD	H	RSD	H	RSD	
NCo376	92	75*	126	79*	218	154	−29
N25	95	72*	147	93*	242	165	−32
N24	93	74*	111	86*	204	160	−22
N19	89	81	149	106*	238	187	−21
N23	82	71	125	104*	207	175	−15
N14	73	60	103	92	176	152	−14
LSD (5%P)	17		18		–	–	–
Means	88	72* (−18%)	127	93* (−27%)	214	166 (−23%)	−23
LSD (5%P)	7		7		–	–	–

Table 6
Yield of recoverable sugar (t/ha) in healthy (H) and RSD infected plots of six varieties under irrigated conditions (plant crop 9,7, first ratoon 11,9 months; *significant at 95% probability).

Variety	Plant crop		First ratoon		P+1R		% loss P+1R
	H	RSD	H	RSD	H	RSD	
NCo376	10,7	9,4	16,5	11,3*	27,2	20,7	−24
N25	11,0	8,9	20,5	12,8*	31,5	21,7	−31
N24	12,2	10,9	18,9	13,9*	31,1	24,8	−20
N19	10,2	10,5	20,0	15,2*	30,2	25,7	−15
N23	9,2	8,9	19,0	14,7*	28,2	23,6	−16
N14	8,9	7,7	13,5	13,4	22,4	21,1	−6
LSD (5%P)	2,3		2,8		–	–	–
Means	10,4	9,4* (−10%)	18,0	13,5* (−25%)	28,4	22,9	−19
LSD (5%P)	1,0		1,1		–	–	–

Table 7
Effect of RSD on cane quality (ers % cane) of six varieties under irrigated conditions (difference between healthy and infected; *significant at 95% probability).

Variety	Plant crop	First ratoon	Mean
NCo376	+0,88	+1,04	+0,96
N25	+1,14*	−0,26	+0,44
N24	+1,21*	−0,92	+0,14
N19	+1,46*	+0,89	+1,18
N23	+1,29*	−1,20	+0,04
N14	+0,71	+1,38	+1,04
LSD (5%P)	1,12	1,55	–
Means	+1,11* (+9%)	+0,16 (+1%)	+0,64 (+5%)
LSD (5%P)	0,46	0,63	–

Table 8
Effect of RSD on stalk population of six varieties under irrigated conditions (*significant at 95% probability).

Crop stage	Plant crop		First ratoon		Means	
Health status	H	RSD	H	RSD	H	RSD
Stalks/ha ($x10^{-3}$)	117	113 (−3%)	142	115* (−19%)	130	114 (−12%)
LSD (5%P)	8		10		–	

1986, 1995). Substantial reductions in yield of recoverable sugar can be expected in most varieties under a wide range of growing conditions. The results have confirmed that stress due to below average rainfall or a shortage of irrigation water exacerbates the effects of RSD on growth and yield.

Because conditions at the two trial sites were relatively favourable compared with 'average' commercial rainfed and irrigated conditions, as indicated by the mean yields of the healthy plots, and because the effects of RSD are greater under poor conditions, the results of both trials can be regarded as underestimating the effects of the disease under industrial conditions.

The results have confirmed that reductions in yield of recoverable sugar are mainly due to reductions in growth, and that stalk height and stalk mass are the growth parameters mainly affected, together with smaller but consistent reductions in stalk populations.

The results of the rainfed trial have again confirmed that RSD has no consistent effect of cane quality. However, in the plant crop of the irrigated trial, the RSD infected plots did have a measurably higher sucrose content. This is the first demonstration of a statistically significant, favourable effect of RSD on cane quality but it did not persist into the first ratoon crop. The overall conclusion from these experiments and those reported previously (Bailey and Bechet, 1986, 1995) is that infection by RSD has no general, favourable effect on cane quality.

These results have confirmed that varieties NCo376 and N14 are particularly intolerant to infection by RSD. They have provided the first evidence that varieties N17 and N25 are also highly intolerant. Varieties N19, N24 expressed intolerance to infection, and varieties N12 and N23 an intermediate but still substantial reduction in growth. From the results of the rainfed trial, variety N22 appears to be relatively tolerant of the effects of RSD.

No good explanation can be offered for the fact the RSD had a lesser effect on variety N14 than on the other varieties in the irrigated trial. This contrasts with all other experimental and survey results with this variety. It may be significant that the cane in the healthy plots of this variety grew much more poorly than expected in both the plant and first ratoon crop.

That substantial losses from RSD occurred in most varieties under irrigated as well as rainfed conditions demonstrates the importance of growers taking routine, precautionary measures to prevent the introduction and spread of RSD into new cane plantings.

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REFERENCES

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 Bechet, GR (1995). The effect of ratoon stunting disease on the yield and of some South African sugarcane varieties under irrigated and rainfed conditions. *Proc S Afr Sug Technol Ass* 69: 74-78.