INFLUENCE OF ROGUING ON THE INCIDENCE OF SMUT IN SWAZILAND

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Abstract

The results of three smut roguing trials are discussed, which show that substantial reductions in the expression of smut infection in NCo376 can be achieved with an intensive roguing programme. Yield increases were evident where roguing was maintained on heavily infected fields. A relationship between % stalk and % stool infection in NCo376 was developed, allowing for comparisons between industries. Data are presented which show the efficiency of roguing on an estate, and which indicate the mandays required to rogue fields with varying levels of smut infection. The decline of smut in the Swaziland sugar industry since 1984/1985 is noted.

Introduction

Sugarcane smut, *Ustilago scitaminea* Sydow, has remained the most prevalent disease of sugarcane in the Swaziland industry for many years. By the summer of 1984/85 surveys showed that the incidence of smut had reached an industrial average of 4,4% stool infection, rising to 11,7% in the Big Bend region and 5,1% in the Nsoko region. This increase in the incidence of smut was largely attributable to an absence of routine roguing in most fields of the highly susceptible variety NCo376, which constituted more than 80% of the area planted to cane in 1984/85. Since then the new, more resistant varieties N14, N17 and N19 have replaced NCo376 only to the extent of about 30 percent, due to the better performance of NCo376 under the varying conditions of moisture stress which exist in the Swaziland industry.

Systematic roguing of diseased shoots or stools as symptoms appear, has long been recognised as an effective check on smut development in the field (Antoine[3]). It has been established that whip roguing in the pre-canopy crop is the most practical method of reducing smut expression in heavily infected fields (James[6] and Bailey[4]). If practiced widely this would lead to lower inoculum levels and a resultant decrease in levels of smut in newly planted fields of NCo376.

The Zimbabwe sugar industry has been successful in reducing the incidence of smut in NCo376 by intensive roguing of commercial cane fields (Anon[1, 2]). From an industry peak of 1,25% stalk infection in 1979/80, infection levels dropped to 0,41% in 1986/87. This reduction in smut levels was seen as a realisable objective for the Swaziland industry.

Yield benefits have been recorded where roguing has been carried out on heavily infected NCo376, increases in sugar yields up to 1,7 tons per hectare being achieved (James[5]). A yield increase has also been noted by Bailey (unpublished data) in a trial on NCo376 in Swaziland where the benefits occurred in a trial block with a comparatively low incidence of smut.

In order to establish whether the reported benefits of roguing were measurable on a field scale, a large replicated plot trial programme was implemented in the spring of 1985 to assess the effect of varying levels of roguing on the expression of smut and the yield of sugarcane and sucrose. The economics of roguing have always been a concern to growers and it was agreed that the use of labour be assessed during the course of the trial programme.

Method

In 1985 three fields of commercially grown NCo376, having smut levels which were representative of those prevailing in the northern and southern areas of the industry, were chosen. In the year preceding commencement of the trial the site chosen on Field 526 (Trial 3) at Mhlume Sugar Company had a smut level of less than 1,0% stool infection. The two sites, Mbabala B and Ngongoni 6 (Trials 1 and 2), chosen at Ubombo Ranches Limited were typical of many of the NCo376 fields in the southern areas of the industry, and had levels of smut exceeding 20% stool infection.

The three trial layouts were identical and comprised six treatments in a randomised Latin square design. The layout of the experiments was determined according to the positions of the dragline irrigation sprinklers. The gross plot was bounded on each site by four sprinkler positions, spaced 18 m apart, making up a block that was 54 metres square. The net plot comprised the 18 metre square that lay in the centre of this block, thus being surrounded completely by similarly treated guard areas.

The net plot was made up of 12 rows spaced 1,5 m apart. The roguing treatments were as follows:

Treatment 1 - No roguing
2 - One roguing 6 weeks after harvest
3 - Two roguings 6 and 12 weeks after harvest
4 - Four roguings 6, 9, 12 and 15 weeks after harvest
5 - Four roguings 6, 12, 18 and 24 weeks after harvest
6 - Eight roguings 6, 9, 12, 15, 18, 21, 24 and 27 weeks after harvest

The roguing practices used were the standard procedures followed on the two estates concerned. The initial roguing of infected material after 6 weeks was carried out by "chipping" infected material away from the actively tillering stool. This procedure continued in subsequent roguings until the crop had reached about 50% canopy, after which infected tillers and stalks were "pulled" from the stool. Due to the high incidence of smut in Trials 1 and 2 all infected material removed from the cane row was left in the interrow.

Inspections to determine levels of smut were carried out in all plots 2 days prior to each roguing date. Infected stools and whips were counted over the entire net plot area of 12 rows (216 metres of row length). Shoot and stalk counts were carried out at 6 week intervals on alternate inspection dates from two 5 metre monitoring sites in each net plot.

The assessment of percent stool infection was calculated on the assumption that a ratoon crop would have 2 stools in each metre of row length (13333 stools/ha). Percent stalk infection was determined on the basis that NCo376 has

155 000 millable stalks/ha at harvest under irrigated conditions.

$$\% \text{ Stool infection} = \frac{\text{No of infected stools/ha} \times 100}{13333 \text{ stools/ha}}$$

$$\% \text{ Stalk infection} = \frac{\text{No of infected whips/ha} \times 100}{155\,000 \text{ millable stalks/ha}}$$

At harvest 4 rows, each 18 m long, were harvested from the net plot and cane yield, sucrose % cane, sucrose yield and millable stalks per hectare were determined.

During the course of the trial it was intended that records of labour use during each of the roguing cycles would be kept. These data were difficult to obtain accurately and recording was subsequently discontinued. Records for two years from Big Bend Sugar Estate have been obtained to illustrate the use of labour and the efficiency of roguing in reducing the expression of smut in commercial sugarcane fields.

Results

Inspection Period

The levels of smut recorded in all three trials at the commencement of the roguing treatments in 1985 (Table 1) indicated uniform levels of infection within each trial block area.

Table 1

Smut infection levels at commencement of roguing trial programme

	% Stool infection			% Whip infection		
Treatment	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1	17,4	14,4	1,8	2,7	3,1	0,4
2	18,2	13,5	1,7	2,8	4,2	0,6
3	14,7	13,8	1,6	2,6	2,8	0,4
4	17,5	14,6	1,7	3,1	3,6	0,4
5	17,9	11,1	1,6	2,9	3,0	0,5
6	18,6	14,7	1,6	2,9	3,8	0,4

The response in smut % stool infection to the roguing treatments was similar within each trial and the inspection data have been averaged for the three crops. The results (Figures 1, 2 and 3) show the pattern of smut expression for the three trials. The responses to roguing were more marked in Trials 1 and 2 which had high levels of smut.

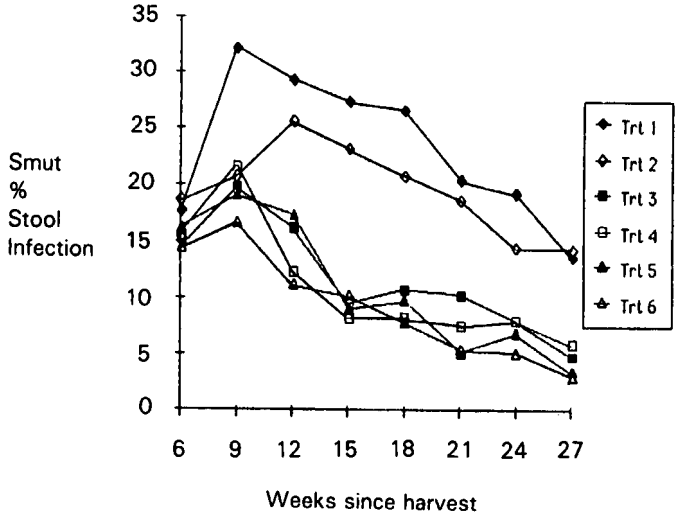

FIGURE 1 Incidence of smut expression Trial 1 (mean of 3 years).

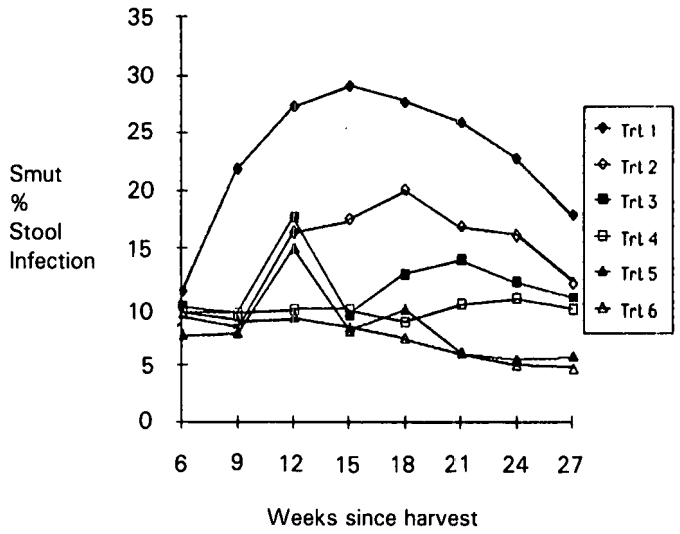

FIGURE 2 Incidence of smut expression Trial 2 (mean of 3 years).

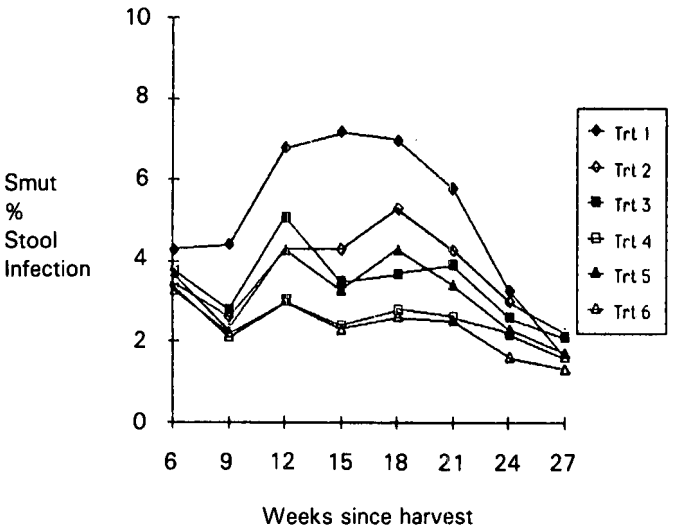

FIGURE 3 Incidence of smut expression Trial 3 (mean of 3 years).

The expression of smut in the unrogued controls (Treatment 1) reached a peak after about 15 weeks in Trials 2 and 3. In Trial 1 the peak occurred after 9 weeks, reflecting the influence of harvest date on the rate of development of smut. Trials 2 and 3 were harvested in July/August and Trial 1 in November of each season. The decline in the apparent incidence of smut after the early peaks was due primarily to the death of infected material, but also to the difficulty in observing smut within the tall canopy of leaves.

A single roguing after 6 weeks (Treatment 2) had a short term effect on the maximum expression of smut and levels generally approached those of the unrogued treatment after about 24 weeks.

The treatment which was rogued after 6 and 12 weeks (Treatment 3) reduced the incidence of smut initially after 9 weeks. This was followed by an increase before declining again after 15 weeks. A slight increase followed before smut levels were masked due to the difficulty in observing the whips in tall cane.

Effective early control was achieved with four roguings after 6, 9, 12 and 15 weeks (Treatment 4) in Trials 2 and 3.

This control was less effective in Trial 1, which generally had the highest level of infection at the commencement of the roguing treatments. This early reduction in smut incidence appeared to diminish later in the roguing period, and the apparent advantage declined relative to the control treatment by 27 weeks.

Four roguings spaced at 6-weekly intervals (Treatment 5) did not achieve the same level of control early in the roguing programme as did Treatment 4, but it was more effective in lowering smut levels after 27 weeks.

The high intensity treatment of roguing eight times at 3-weekly intervals, (Treatment 6) was the most effective in reducing smut levels continually throughout the period from 6 to 27 weeks.

The different intensities of roguing had little effect on the number of tillers and stalks at the end of the roguing period (Table 2). There were also no indications that the roguing treatments had any effect on the number of tillers after 6 weeks in the following crop cycle. The relationship between % stool infection and % stalk infection, plotted from the treatment means for the 1985/86 season in Trial 2, is shown in Figure 4. A natural log transformation of the data showed the essentially linear relationship illustrated in Figure 5.

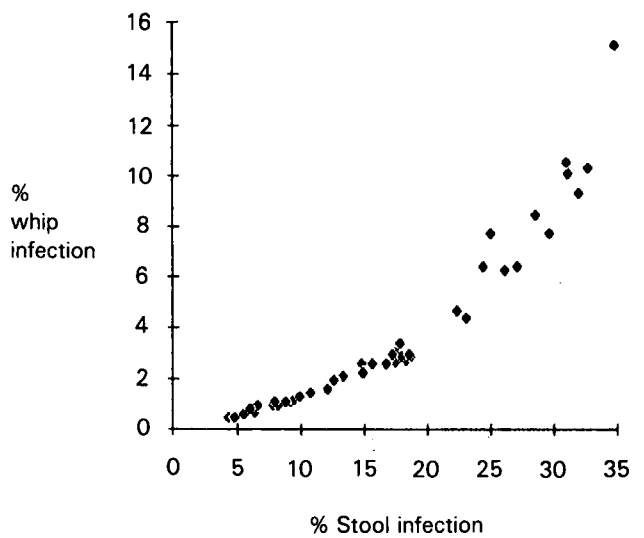

FIGURE 4 Relationship between % stool and % whip infection levels in NCo376 (Trial 2 - 1985/86 treatment means).

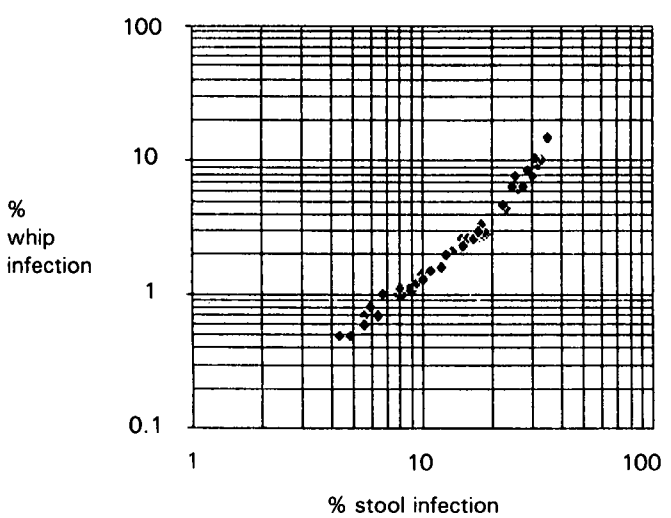

FIGURE 5 Natural log transformation of the relationship of % stool infection to % whip infection in NCo376 (Trial 2 - 1985/86 treatment means).

The regression coefficients for all three trials (Table 3) show a consistent pattern over the three seasons. The transformed data lead to a closer correlation, which is indicative of an exponential increase in the numbers of infected stalks relative to stool numbers as the level of infection rises.

Harvest

It was apparent that the varying roguing intensities had no significant effect on the millable stalk populations at harvest (Table 2) although in Trials 1 and 2, which had high levels of smut, there were indications of an increase in millable stalks with an increase in the number of roguings.

The yield results indicated an improvement in tons cane per hectare harvested in Trials 1 and 2 (Table 4) with increased levels of roguing. This trend was significant ($P = 0,05$) in the last two harvests of Trial 2. There were no apparent differences in cane yield between treatments in Trial 3 where the incidence of smut was much lower.

Roguing had no significant effect on the quality of cane, with the result that the relative yields of sucrose were similar to those of cane (Table 5).

Table 2

Stalk populations at end of roguing period and at harvest

	Stalks (1 000's per hectare)					
	at 24 weeks			at harvest		
Treatment	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1	184	294	166	160	155	160
2	187	304	161	163	162	163
3	181	310	171	160	157	161
4	183	318	164	174	156	166
5	179	297	184	165	163	162
6	183	306	165	176	165	160

Table 3

Regression coefficients of % stools vs % stalk infection in NCo376 (mean of 3 years for each trial)

Regression Coefficients	Linear (y = a + bx)				Natural Log (y = ax^b)			
	Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean
a	-1,82	-1,26	-0,14	-1,07	0,06	0,09	0,15	0,10
b	0,34	0,31	0,26	0,30	1,43	1,31	1,24	1,33
r	0,91	0,91	0,92	0,91	0,93	0,93	0,94	0,93

Labour Use

The monitoring of commercial roguing on Big Bend Sugar Estate during the summers of 1986/87 and 1987/88 produced data to illustrate the effectiveness of roguing and the number of mandays required to reduce and contain the levels of smut on the estate. Inspection surveys were carried out on the day preceding and within 2 days after the day of roguing. The data show that the visible symptoms of smut were reduced on average by about 80% (a ration of 5:1) during the course of a commercial roguing operation (Figure 6).

Table 4
Cane yield responses to different levels of roguing in NCo376

	Tons cane per hectare										
	Trial # 1 (high smut levels)				Trial # 2 (high smut levels)				Trial # 3 (low smut levels)		
Treatment	86/87	87/88	88/89	mean	86/87	87/88	88/89	mean	86/87	88/89	mean
1	94	94	112	100	99	116	111	109	116	102	109
2	97	97	116	103	114	118	119	117	114	101	108
3	102	102	125	110	102	115	108	108	115	100	107
4	97	99	113	103	101	121	120	114	116	103	110
5	100	103	123	108	106	128	126	120	114	100	107
6	101	101	120	107	112	133	129	125	117	100	108
P = (0,05)	N.S	N.S	N.S	-	N.S	12	19	-	N.S	N.S	-
CV%	12	11	10		14	8	24		7	8	
SE mean	6	4	4		6	4	7		3	3	

Table 5
Sucrose yield responses to different levels of roguing in NCo376

	Tons sucrose per hectare										
	Trial # 1 (high smut levels)				Trial # 2 (high smut levels)				Trial # 3 (low smut levels)		
Treatment	86/87	87/88	88/89	mean	86/87	87/88	88/89	mean	86/87	88/89	mean
1	18,3	15,6	14,6	16,2	14,9	17,3	17,5	16,6	17,6	14,5	16,1
2	18,9	16,1	14,8	16,9	16,9	17,5	19,0	17,8	17,3	14,8	16,1
3	20,7	16,6	15,5	17,6	15,1	17,0	17,5	16,5	17,6	14,9	16,3
4	18,6	16,7	14,9	16,7	15,0	17,9	19,0	17,3	17,6	14,4	15,9
5	20,7	17,3	15,4	17,8	15,8	18,9	20,1	18,3	17,6	14,4	16,0
6	20,0	17,0	15,4	17,5	16,2	19,5	20,2	18,6	17,7	14,1	15,9
P = (0,05)	N.S	N.S	N.S	-	N.S	1,8	N.S	-	N.S	N.S	-
CV%	11,7	10,2	11,0		12,5	8,2	12,5		6,6	7,9	
SE mean	0,9	0,7	0,7		0,8	0,6	1,0		0,5	0,5	

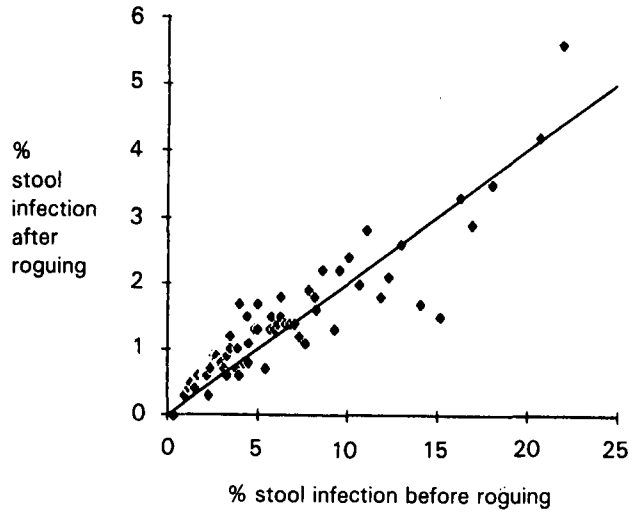

FIGURE 6 Reduction in % stool infection in NCo376 following commercial roguing on Big Bend Sugar Estate.

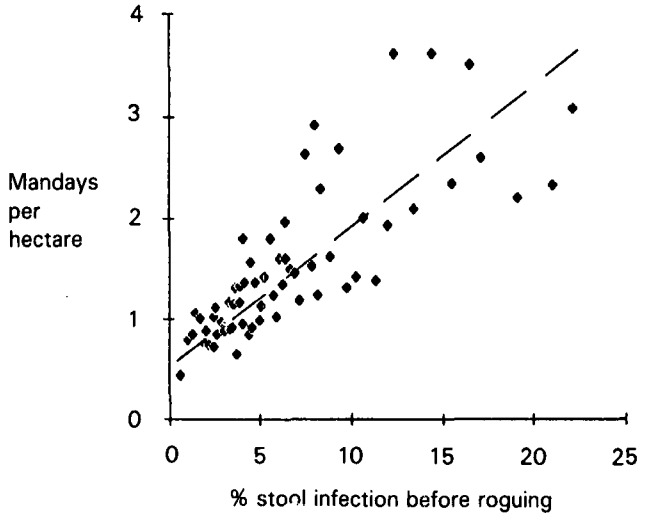

FIGURE 7 Utilization of labour on Big Bend Sugar Estates to rogue smut in NCo376.

The labour requirement in mandays per hectare was shown to be dependent upon the level of smut infection (Figure 7). It was apparent that the minimum labour requirement was unlikely to be less than 0,5 mandays per hectare. As the level of smut infection rose above 2 or 3%, the labour requirement appeared to increase at a rate of about 0,2 mandays for every 1% increase in stool infection.

Discussion

The results of the pre- and post-roguing inspection surveys carried out on Big Bend Sugar Estate (Figure 6) show that the recommended techniques of roguing can reduce the level of smut expression by about 80% at the completion of each

roguing operation. Because the mean data for 3 years from the 3 trials indicate the infection levels 3 weeks after roguing (Figures 1, 2 and 3), they do not provide a fair measure of the immediate reduction in smut counts following roguing. The observations made on an estate scale confirm the results of the 3 trials, viz. that a sustained lowering of smut expression in fields with over 20% stool infection, can be achieved only with a programme of regular roguing during the first 6 months of growth.

The close correlation between % stool and % stalk infection (Figure 5) permits a comparison to be made between sugar industries growing variety NCo376. It is apparent that the maximum smut levels of between 1,23 and 3,27% whip infection (analogous to % stalk infection) in NCo376 experienced by the Zimbabwe industry in 1979/80 (Anon[1]) is comparable with the Swaziland levels of 1984/85, where the industry average was 4,4% stool infection and the maximum was 11,7%. The success of the Zimbabwe industry in lowering smut levels during the past decade indicates that roguing can provide a realistic goal for the Swaziland industry. The result of surveys in the Big Bend region for the period from 1984/85 to 1988/89 (Table 6) show a remarkable decline in the incidence of smut; which can be attributed to improved roguing programmes and to the substantial decline in the area (about 30%) planted to NCo376. It must be emphasised that the potential for smut to be a severe problem in the industry is unlikely to have declined, and the results support previous findings (James[7]) that the roguing of fields with a high incidence of smut will reduce the smut hazard. A concerted effort is required to maintain smut at the lowest possible level by reducing the inoculum pressure on the younger ratoons of NCo376 and the new variety releases, thereby leading to a more significant lowering of the incidence of smut in the industry as a whole.

Table 6

Trends in smut incidence in the Big Bend region between 1984/85 and 1988/89

Period of smut survey	% area planted to NCo376	Smut: % stool infection	
		All varieties	NCo376
1984/85	70,9	11,7	18,4
1985/86	63,4	9,8	13,2
1986/87	54,8	7,2	10,5
1987/88	47,7	5,9	9,8
1988/89	31,3	4,0	7,0

Stalk populations at harvest were relatively unaffected by the roguing treatments. The cane and sucrose yields in Trials 1 and 2 indicated that increased yields can be expected from the frequent roguing of cane fields heavily infected with smut.

The data obtained on Big Bend Sugar Estate indicate that commercial roguing will generally remove only 80% of the visible smut. This apparent inefficiency might be partly overcome with more diligence, but perhaps more labour will be needed if a significant improvement is to be made. The relationship between % stool infection and the number of mandays required for roguing per hectare, appears to indicate a reasonably consistent ratio of 0,2 mandays/hectare/1% stool infection.

Conclusion

The results of the 3 field trials illustrate that by efficient roguing of smut in NCo376 economic advantages can be achieved.

The Swaziland sugar industry is still heavily dependent on NCo376 to achieve optimum sucrose production on soils where the climatic potential cannot be realised. The roguing of smut in fields of NCo376 with low levels of infection must be considered as a preventive measure to ensure that airborne inoculum levels are maintained at the lowest possible level. Roguing of smut from fields with high levels of smut infection can lead to significant yield increases which are likely to more than offset the cost of labour required to maintain the infection at acceptable levels.

Acknowledgements

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REFERENCES

1. Anon (1986). Report for 1984 and 1985. Zimbabwe Sug Ass Exp Stn, p 188.
2. Anon (1988). Report for 1986 and 1987. Zimbabwe Sug Ass Exp Stn, p 99.
3. Antoine, R (1961). *Sugar Cane Diseases of the World. Vol 1.* Elsevier, Amsterdam.
4. Bailey, RA (1977). Sugarcane smut in South Africa: current control recommendations. *Proc S Afr Sug Technol Ass* 51: 47–50.
5. James, GL (1972). Roguing and its effects on yield and Smut of Sugarcane. *Sugarcane Pathologists Newsletter* 9: 20–22.
6. James, GL (1973). Effects of roguing on yield and smut of sugarcane. *Expt Agriculture* 9:73.
7. James, GL (1974). Culmicolous Smut of sugarcane and the effects of its control on yield. *Proc int Soc Sug Cane Technol* 1: 292, 299.