A PRELIMINARY REPORT ON THE INCIDENCE OF RED ROT IN THE SOUTH AFRICAN SUGARCANE INDUSTRY

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Abstract

A preliminary survey was conducted to provide an estimate of the severity of red rot (*Glomerella tucumanensis*) in various parts of the sugar industry. The incidence of this disease was greater in the higher altitude areas, with long growing cycles, and where crops were damaged by sesamia or eldana borers. The most severe case observed was 52% of stalks of NCo376 infected in a field at Kranskop. Survey data demonstrated differences in the susceptibility of varieties similar to those observed with mechanical inoculation.

Introduction

Red rot is one of the oldest known diseases of sugarcane and is also one of the most widely distributed. It was first described from Java in 1893 (Went[8]) and was soon observed in most cane producing countries. Red rot has caused the failure of numerous sugarcane varieties and from time to time has had serious economic consequences in various sugar industries, including Australia, the continental United States, Hawaii and India. It remains an important disease in most sub-tropical areas in which sugarcane is grown (Singh and Singh[7]).

Red rot was first identified in South Africa with certainty in 1941 (McMartin[4]), although an earlier record suggests that it may have been present as a minor disease from 1919 (McClean[3]). The outbreak of the early 1940's occurred in varieties Co290 and POJ2725 in the Eshowe, Upper Tongaat and Powerscourt areas and reductions in yield of up to 50% were reported as being 'not uncommon' (McMartin[4]). The disease was widespread in the cooler, southern and inland parts of the industry in the mid to late 1970's, often causing severe damage in varieties NCo293, NCo376, NCo382, N55/805 and N6 (Bailey[1]).

Red rot is caused by the fungus *Glomerella tucumanensis* (Speg.) Arx and Mueller. It can infect any part of the sugarcane plant but is important mainly as a disease of the standing cane stalks (Figure 1), seedcane and stubble. Lesions often occur on the leaf midribs (Figure 2), but are not important except as sources of inoculum for infection of the stalks (Singh and Singh[7]). Infection of the stalks is facilitated by mechanical injury, such as growth cracks, injuries to buds and leaf scars, and insect borings (Edgerton[2], Sandhu *et al*[5]).

Losses in yield caused by red rot result from poor stands (due to infection of the seedcane or stubble), reduced cane quality (due to the enzymatic inversion of sucrose) and to

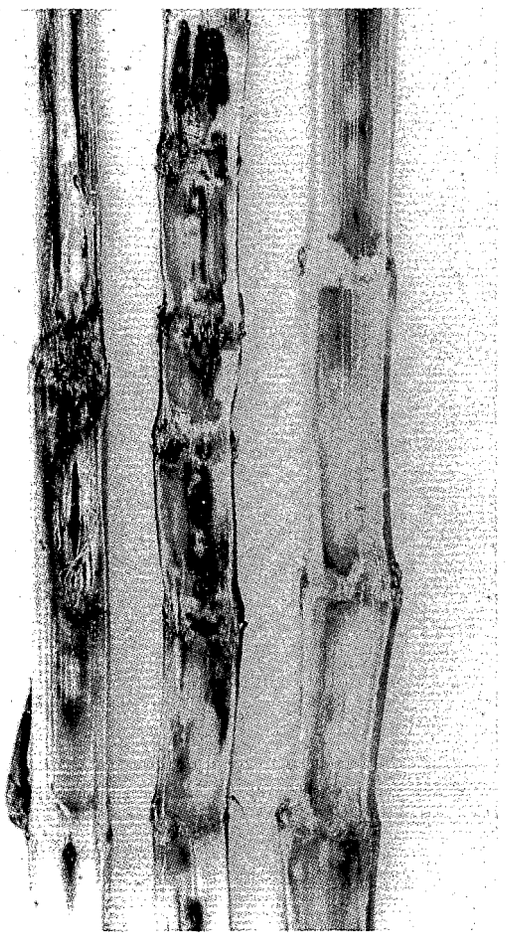

FIGURE 1 Cane stalks severely damaged by red rot.

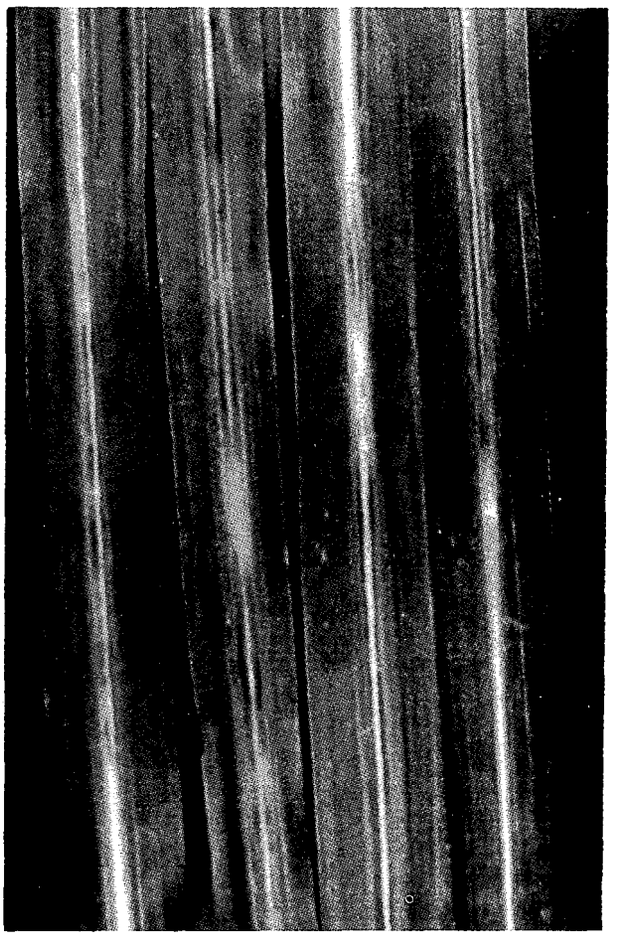

FIGURE 2 Red rot lesions on leaf midribs.

the death of growing plants (Singh and Singh[7]). The extent of losses depends on varietal susceptibility and environmental conditions. In South Africa red rot is most serious in the cooler growing areas (Bailey[1], McMartin[4]) and this is probably partly due to the relatively old age of the crop where it is harvested in these areas.

Red rot does not cause obvious symptons on the outside of the stalks, unless it is very severe so that stalks die. The importance of red rot has probably therefore been underestimated in the past. The purpose of this survey was to determine the severity of red rot in different parts of the industry and to determine which varieties were the most susceptible. A supplementary investigation into varietal susceptibility by means of inoculation was also conducted.

Methods

Field survey

The survey was conducted in 10 areas in Natal, ranging in altitude from near sea level to 1 200 m above sea level and extending from Paddock in the south to Darnall in the north; thus it comprised approximately the southern third of the cane belt (Table 1). Samples were taken from a total of 691 fields on 120 farms. Eighty-five farms and 537 fields were located in the Dalton, Eston, Darnall and Gledhow areas, so covering the range of altitude from the Natal Midlands to the coast. The survey was conducted over the period August to October 1988.

Table 1
Number of farms and fields and the altitude of areas surveyed for red rot

Area	No. of farms	No. of fields	Altitude (m)
Dalton	23	184	800–1 100
Darnall	20	70	0– 200
Eston	26	177	600– 900
Gledhow	16	106	0– 300
Glendale	6	30	400– 700
Harding	4	16	600– 900
Kranskop	4	17	1 100–1 200
Paddock	2	9	300– 900
Sezela	9	36	0– 900
Tongaat	10	46	0– 300
Totals	120	691	

The crops from which the samples were taken were due to be harvested, but they varied considerably in age. Variation in crop age at sampling was partly because of differences in crop maturity between areas. Mean crop ages in the different areas are shown in Table 2 and in Appendix 1.

One hundred stalks were taken at random from each field and were split and examined. The following data were recorded: variety, age, number of stalks with red rot, number of internodes affected per stalk, number of infection sites per stalk, number of stalks with insect borings and numbers of sesamia and eldana larvae and pupae per 100 stalks (S/100 and E/100 respectively). Random samples were plated on potato dextrose agar (PDA) to confirm the presence of *Glomerella tucumanensis.*

Inoculation experiment

Glomerella tucumanensis was isolated from field-grown cane and cultured on PDA. A suspension of conidia in sterile water (2×10^5/ml) was used to inoculate standing stalks of cane of six varieties. The stalks were selected in a plant cane crop, 9 months old, that had been established with hot water treated seedcane. The varieties were NCo376, N12, N13, N14, N17 and N18. These included widely grown and promising varieties and also two (NCo376 and N13) in which severe red rot had been observed in the field.

Forty stalks of each variety were each inoculated with 0,25 ml of spore suspension injected at one point in the centre of the stalk, using a hypodermic syringe and 13 gauge needle. The point of inoculation was located approximately one third up the length of the stalk from the ground and at the mid point of an internode. Control stalks were injected with 0,25 ml sterile water or were uninjected.

Stalks were collected from the field on six occasions at various intervals from 6 to 84 days after inoculation and were split and examined. The length, width and colour of the area with red rot and the number of internodes affected were recorded.

Results and discussion

Field survey

Ten varieties were included in the survey. Of the 691 fields sampled, 46% were planted to NCo376, 22% to NCo293, 17% to N12 and 8% to N11. Varieties NCo382, N55/805, N13, N14, N16 and N18 were represented by only small numbers of fields. The extent to which different varieties were sampled in the different areas varied considerably. NCo376 made up 77% of samples in the five coastal areas followed by N12 (14%); whereas samples from the inland areas mainly comprised NCo293 (38%), NCo376 (24%), N12 (20%) and N11 (12%). These proportions closely reflect the varietal composition in the areas sampled.

The mean age of all the crops at sampling was 15,5 months but there were marked differences in the mean ages of crops between areas (Table 2), between varieties (Table 3) and

Table 2
Frequency of insect borings and incidence or red rot in different areas of Natal, 1988

Area	No. of fields	Mean age (mths)	Sesamia (S/100 stalks)	Eldana (E/100 Stalks)	% stalks bored	% stalks with red rot	Internodes per stalk with red rot
Kranskop	17	23,8	3,9	0	22,5	26,4	0,86
Gledhow	106	9,8	2,0	12,8	31,8	28,0	0,65
Paddock	9	19,1	1,2	0,1	29,3	24,8	0,56
Eston	177	18,3	0,4	0,3	14,3	22,0	0,52
Harding	16	21,8	0,7	0,1	14,1	21,5	0,50
Sezela	36	18,9	2,1	1,5	22,1	16,2	0,41
Tongaat	46	11,9	2,1	5,2	26,4	14,4	0,40
Darnall	70	11,9	2,4	5,3	24,6	19,5	0,33
Dalton	184	17,2	1,0	0,1	13,9	11,2	0,31
Glendale	30	11,9	1,5	1,7	11,7	11,1	0,16
Total & weighted means	691	15,5	1,4	3,1	19,4	18,5	0,44

Table 3

Frequency of insect borings and incidence of red rot in different varieties

Variety	No. of fields	Mean age (mths)	Sesamia (S/100 stalks)	Eldana (E/100 Stalks)	% stalks bored	% stalks with red rot	Internodes per stalk with red rot
N13	11	14,3	1,7	4,6	22,7	30,5	0,67
NCo376	317	14,0	1,7	5,7	23,4	20,6	0,51
NCo293	154	18,3	0,9	0,4	15,2	19,8	0,49
N55/805	4	12,8	0,5	7,5	21,0	19,5	0,42
N11	55	15,3	1,0	0	17,1	13,9	0,34
N16	15	15,3	1,3	0	13,7	10,8	0,29
N12	119	16,7	1,2	1,3	16,0	14,8	0,27
N18	4	14,5	0,1	0	9,3	11,8	0,22
N14	8	10,9	1,3	3,5	18,9	6,6	0,21
NCo382	4	18,0	1,0	0	11,3	7,0	0,15
Total & weighted means	691	15,5	1,4	3,1	19,4	18,5	0,44

among varieties within individual areas. The data are summarised, according to the varieties within each area, in Appendix 1.

A mean of 18,5% of stalks of all the samples examined and a mean of 0,44 internodes per stalk were found to be infected by red rot. The highest proportions of infected stalks, 28,0 and 26,4% respectively, were recorded at Gledhow and Kranskop, followed by Paddock, Eston and Harding, all with more than 20% infected stalks (Table 2). If the number of infected internodes is used as an index of damage (Srinivasan and Bhat[6]), a similar ranking of areas is obtained, with the extent of damage in the five most severely affected areas ranging from 0,9 infected internodes per stalk at Kranskop to 0,5 at Harding (Table 2). Four of the five areas with the highest levels of red rot are situated in the cooler, inland parts of the industry and had a mean crop age at sampling of 20,8 months. In contrast mean crop age in the five areas with the least red rot was 14,4 months.

Assessment of varietal susceptibility to red rot from the survey data must have been complicated by the different mean ages of the varieties at the time of sampling. Nevertheless the data suggest that N13 was the most susceptible; it had the highest percentages of infected stalks and internodes at a mean age below that of most of the other varieties (Table 3). Varieties NCo293 and NCo376 had the next highest numbers of infected stalks and internodes, though NCo293 was older on average. It appeared also that N11, N12, N14 and N16 were less susceptible than N13 and NCo376.

When the survey data are presented there is a clear association between the incidence of red rot and the number of stalks bored by insect larvae both on the basis of area and of variety (Figures 3 and 4). As expected, the main insect borer was eldana in the coastal areas and sesamia in the cooler, inland areas (Table 2). No correlation between crop age and frequency of insect borings was observed.

The most severe cases of red rot, in which more than 30% of stalks were infected, are presented in Table 4. The worst three cases, based on the number of infected internodes, occurred in cool inland areas in crops aged 19,5 months or more. In the two worst cases, at Kranskop and Paddock, 52 and 43% of stalks respectively were infected. Of the three cases in the coastal areas, at Darnall and Gledhow, two involved variety N13.

Although red rot was generally most common in the cooler areas and least common near the coast, contrasting observations were made at Dalton (cool and inland) and Gledhow (coastal). At Dalton, the mean incidence of red rot was 11,2% infected stalks (0,3 infected internodes per stalk) and this

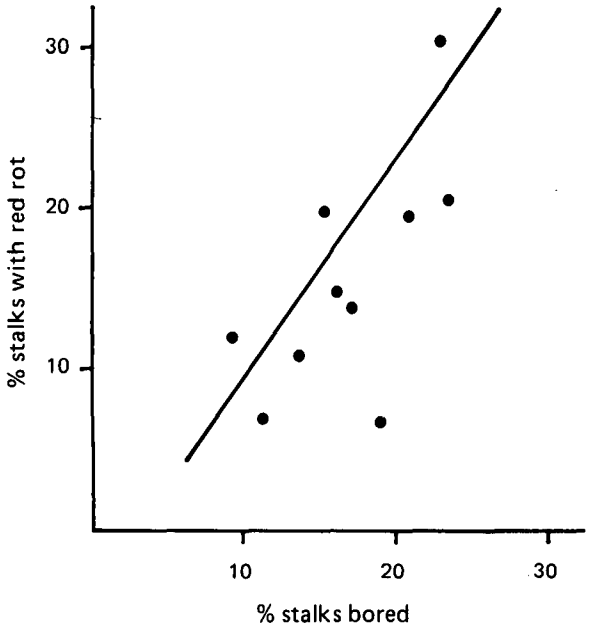

Figure 3 Relationship between % stalks bored and % stalks with red rot in different varieties.

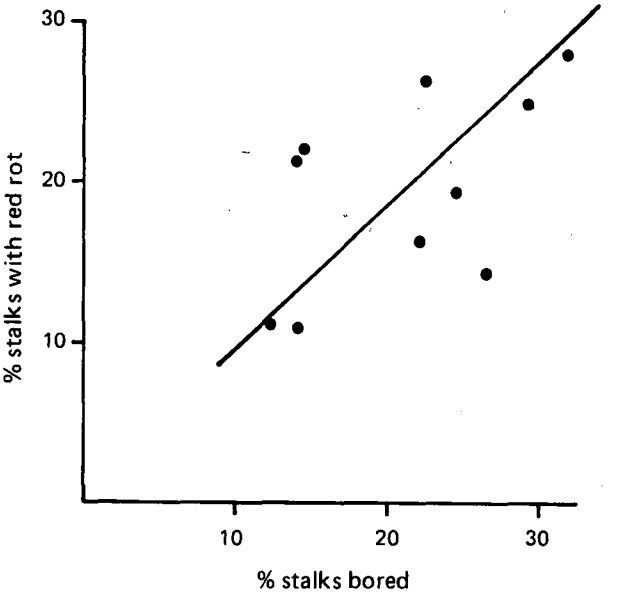

Figure 4 Relationship between % stalks bored and % stalks with red rot in different areas.

Table 4

Varieties in different areas with more than 30% of stalks infected by red rot.

Area	Variety	No. of fields	Age (mths)	Sesamia (S/100 stalks)	Eldana (E/100 stalks)	% stalks bored	% stalks with red rot	Internodes per stalk with red rot
Kranskop	NCo376	5	25,8	8,0	0	45,2	52,0	2,10
Paddock	N12	2	19,5	1,5	0	58,5	43,0	0,98
Harding	NCo376	5	23,4	0	0,2	16,8	34,6	0,94
Gledhow	N55/805	2	13,0	0	15,0	36,0	36,0	0,81
Gledhow	N13	3	10,3	3,0	11,0	33,0	32,3	0,80
Darnall	N13	2	13,5	3,0	4,0	24,0	38,5	0,41

was the second lowest of the 10 areas (Table 2). However, the mean crop age at Dalton, 17,2 months, was the lowest in the inland areas and the crops had the fewest insect borings. The high incidence of red rot at Gledhow (28,0%) was associated with a mean crop age of only 9,8 months, but these crops had the highest percentage of stalks bored by insects, as well as the highest level of eldana (12,8 E/100 stalks) of all the areas (Table 2).

Red rot was found to occur mainly in the lower third of the cane stalk. In lodged cane, infection often occurred at bends in the stalk. In addition to entry through insect borings, other sites of infection were buds and leaf scars at the nodes and cracks in the stalks.

Inoculation experiment

Six days after inoculation extensive red rot lesions developed within the stalks of all six varieties. Differences in the extent of lesion development between varieties remained fairly constant over the sampling period and because only 5 or 10 stalks per variety were examined on each sampling date, mean data from the 40 inoculated stalks of each variety are presented in Figure 5. There was a positive correlation between lesion length and width. Because of variability in stalk and internode length within and between varieties, the number of internodes infected by red rot is included as an index of susceptibility.

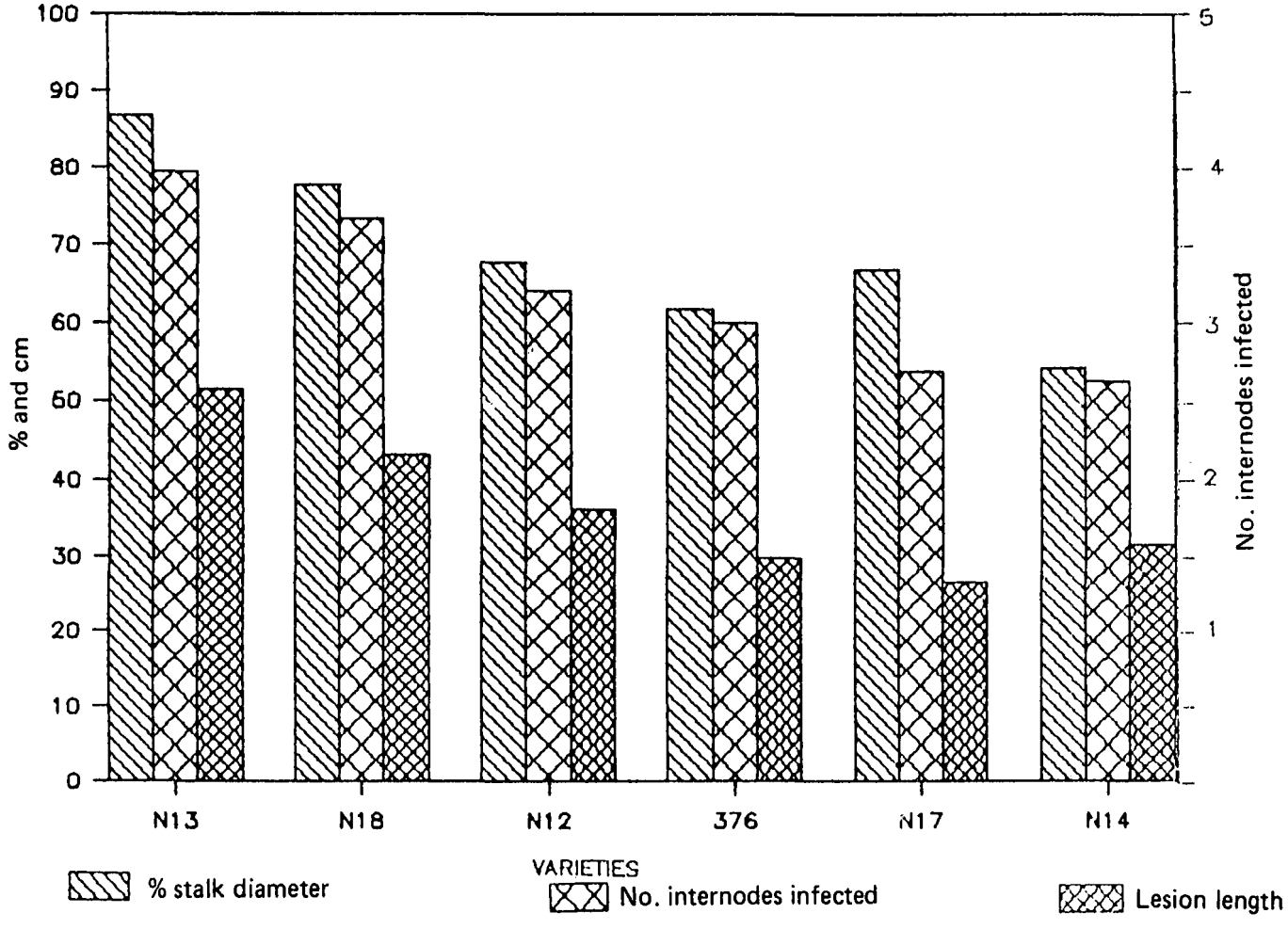

FIGURE 5 Lesion width (% of stalk diameter), number of internodes infected and lesion length (cm) after inoculating cane stalks with *Glomerella tucumanensis* (means of 40 stalks per variety at a mean of 6 weeks after inoculation).

Judged by the extent of lesion development N13 was clearly the most susceptible of the six varieties, followed by N18. N14 was the least susceptible and N12, N17 and NCo376 were intermediate (Figure 5). The relative susceptibility of N13 and N18 was confirmed by the consistent occurrence of the characteristic 'white spots' of red rot in the lesions of N13 and their occasional occurrence in N18, whereas white spots did not develop in the other varieties. These white spots are reported to be most common in susceptible varieties (Singh and Singh[7]).

According to Srinivasan and Bhat[6] lesion colour can also be used as an indicator of susceptibility; resistant varieties having dark red, small lesions whereas lesions in susceptible varieties are larger and bright red. In the six varieties under investigation N13 had light orange (susceptible) lesions; NCo376, N14, and N18 had lesions of intermediate colour, and N12 and N17 had dark red lesions indicative of resistance. The difference in the appearance of lesions in N12 and N13 is illustrated in Figure 6.

The results from the inoculation experiment are therefore in broad agreement with the ranking of varietal susceptibility according to the survey data. The main exception is N18, but it is probably significant that this variety had the lowest incidence of insect borings in the survey and was also represented by only four fields.

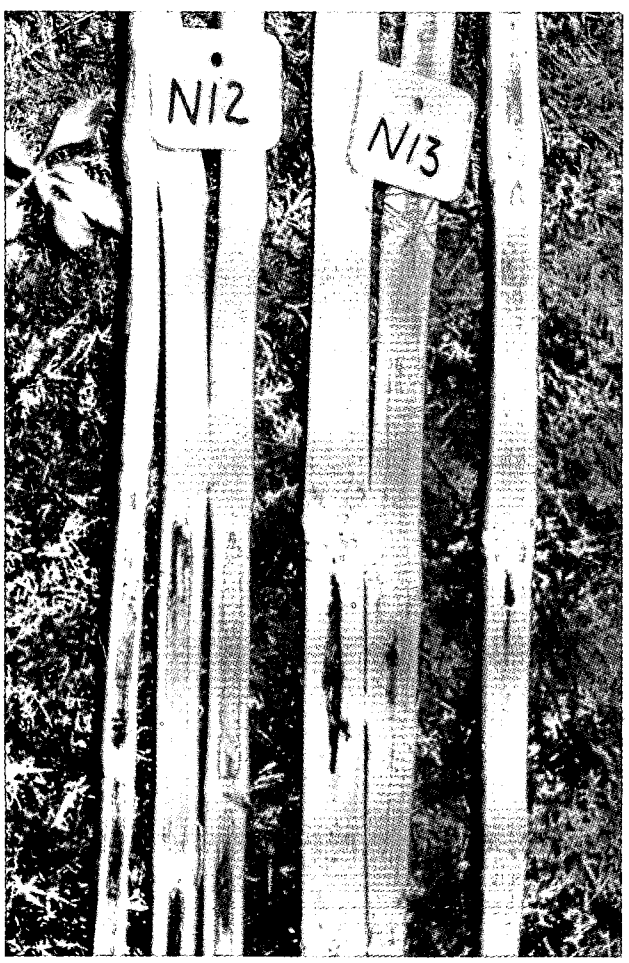

FIGURE 6 Red rot lesions after inoculating stalks of N12 (intermediate–resistant) and N13 (susceptible).

Conclusions

The survey demonstrated the current substantial occurrence of red rot in the southern, rainfed parts of the South African sugar industry. The highest levels of the disease occurred mainly in the cooler areas, with the longest growing cycles, but high levels also occurred in young cane near the coast. Borings in the stalks by sesamia and eldana proved to be important points of infection for red rot.

The worst incidence observed was in five fields of NCo376 at Kranskop, where 52% of stalks and more than two internodes per stalk were infected. Substantial loss in yield of sucrose must occur at these high levels of infection but further work is needed to determine the extent of losses caused by the disease.

Differences in the susceptibility of varieties to red rot were detected in the survey and these were in broad agreement with the results of the inoculation experiment. A tentative ranking of varieties based on the results of the survey and the inoculation experiment is N13 (most susceptible); N18; NCo376; NCo293; N11, N12, N16; N14 (least susceptible). Inoculation of standing cane shows promise as a means of estimating varietal susceptibility to red rot.

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APPENDIX 1

Mean for each variety in each area

Area	Variety	No. of fields	Age (mths)	Sesamia (S/100 stalks)	Eldana (E/100 stalks)	% stalks bored	% stalks with red rot	No. internodes infected per 100 stalks
Sezela	NCo376	20	16,9	2,4	2	21	18,1	58,9
	N11	5	20	1,4	0,3	23,6	20,3	39,7
	N12	8	22,9	1,8	0,2	17,4	8,8	13,7
	N16	3	22,0	2,0	0	14,7	13,3	31,3
Harding	NCo293	8	20,3	1,0	0	14,6	19,3	39,0
	NCo376	5	23,4	0	0,2	16,8	34,6	94,0
	N12	3	23,0	1,0	0	8,5	5,5	7,0
Paddock	NCo293	2	24,0	0,5	0	27,5	27,0	82,5
	NCo376	5	17,0	1,4	0,2	18,4	16,6	28,2
	N12	2	19,5	1,5	0	58,5	43,0	97,5
Glendale	NCo376	28	12,3	1,4	1,8	11,7	11,2	16,2
	N12	2	7,0	2,5	0	11,0	8,5	13,0
Kranskop	NCo293	9	22,9	2,2	0	14,6	16,9	38,7
	NCo376	5	25,8	8,0	0	45,2	52,0	210,4
	N12	3	23,0	2,0	0	8,3	12,0	17,7
Gledhow	NCo376	86	10,3	2,0	10,8	30,4	25,3	54,7
	N55/805	2	13,0	0	15,0	36,0	36,0	80,5
	N12	13	10,3	2,7	6,6	24,2	24,6	42,6
	N13	3	10,3	3,0	11,0	33,0	32,3	80,0
	N14	2	6,0	0,5	6,5	15,5	12,0	27,0
Eston	NCo293	55	18,5	0,5	0,5	16,2	27,8	72,3
	NCo376	53	19,9	0,6	0	13,0	24,7	59,8
	N11	16	16,9	0,3	0	15,4	15,9	34,4
	N12	41	17,3	0,2	0	14,9	17,4	31,0
	N13	6	17,9	0,5	2,5	18,6	29	83,4
	N16	4	16,8	0	0	10,0	16,5	30,0
	N18	2	12,0	0	0	9,0	16,0	35,0
Darnall	NCo376	49	11,7	2,5	5,0	24,0	19,5	32,3
	N12	17	11,8	2,1	4,9	22,0	15,0	27,7
	N13	2	13,5	3,0	4,0	24,0	38,5	40,5
	N14	2	12,0	1,0	7,5	27,5	2,5	19,0
Tongaat	NCo376	38	11,9	2,1	14,5	32,8	12,2	47,3
	N14	2	10,5	3,0	0	23,5	9,5	31,0
	N16	6	13,0	1,8	0	18,5	8,3	34,3
Dalton	NCo293	80	20,3	0,6	0,1	14,3	14,9	38,8
	NCo376	28	16,7	0,6	0,2	13,7	4,6	33,6
	NCo382	4	18	1,0	0	11,3	7,0	15,0
	N55/805	2	12,5	1,0	0	6,0	3,0	3,5
	N11	34	15,6	1,2	0	1,2	11,2	28,3
	N12	30	18,3	0,8	0	11,4	6,7	17,1
	N14	2	15,0	0,5	0	9,0	2,5	6,5
	N16	2	9,5	1,0	0	5,5	3,5	8,0
	N18	2	17,0	0,5	0	9,5	7,5	8,5