SCREENING OF NEW SUGARCANE GENOTYPES FOR RESISTANCE TO RED ROT (GLOMERELLA TUCUMANENSIS)

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Abstract

Preliminary investigations in South Africa into determining the resistance of sugarcane varieties to red rot (*Glomerella tucumanensis*) by means of an inoculation procedure, conducted in 1988-89, showed promise. Results of these trials, together with findings from industry-wide red rot surveys in the late 1980s, were used to provide a preliminary ranking of a number of released varieties. Variety N13 was found to be highly susceptible, whereas N12, N16 and N14 were rated as resistant.

Three trials of advanced selections and additional released varieties have since been completed. Most of the released varieties tested were found to be resistant or moderately resistant to red rot. However, 15% of the 93 new genotypes in the final stages of selection, were found to be more susceptible than N13 and were considered too susceptible for further selection. Screening for red rot resistance in the variety selection programme is now a routine operation.

Keywords: sugarcane, red rot, screening, resistance

Introduction

Red rot, caused by the fungus *Glomerella tucumanensis* (Speg.) Arx and Mueller, was first described as a disease of sugarcane from Java in 1893 (Went, 1893). It is therefore one of the oldest known diseases of sugarcane. Following this first description, red rot was soon observed in other cane producing countries and it is now one of the most widely distributed diseases of sugarcane. It has caused the failure of a number of varieties and has had serious economic effects in many subtropical countries (Singh and Singh, 1989).

Red rot was first identified in South Africa in 1941 by McMartin (1943). It caused considerable damage in varieties Co290 and POJ2725 in the Eshowe district in the early 1940s (McMartin, 1943). The disease was found to be widespread in the cooler, southern and inland parts of the industry in the 1970s, causing damage in a number of varieties including NCo376 (Bailey, 1979).

Although the fungus may infect any part of the cane plant, red rot is usually classed as a disease of the stalk, where it causes most damage. Infection can result in a reduction in stalk mass, in stalk death and, because of the pathogen's ability to invert sucrose, a reduction in cane quality. Germination may be adversely affected when seedcane and stubble become infected. In South Africa, infection of the leaf midrib is often seen in a number of varieties, such as N14, but this is of little direct importance.

Red rot occurs in all parts of the industry but is most common and damaging in the cooler, upland areas (Trenor and Bailey, 1989). Fluctuations in the importance of red rot from year to year are mainly due to variations in the weather. Infection and consequent damage are most likely to occur when the cane is stressed due to excessive or deficient moisture and also in old cane (Bailey, 1979). Because stressed and old cane is more likely to suffer damage from stalk borers, such as eldana and sesamia, and because damage from stalk borers provides a ready site of infection for *G. tucumanensis,* the severity of red rot in South Africa is exacerbated in poor seasons when the incidence of stalk borers is high. A direct relationship between the frequency of stalk borings and the incidence of and damage from red rot was demonstrated by Trenor and Bailey (1989).

As the symptoms are usually not readily observable in the field without the detailed examination of stalks, the importance of red rot is often underestimated. The results of industry wide surveys conducted in 1988-89 and 1989-90, both seasons of relatively good rainfall, were similar and showed that a mean of 0,45 internodes per stalk was infected (Trenor and Bailey, 1989; Anon., 1990). This indicated a 1-2% loss in annual production from red rot in those seasons (Anon., 1989). Losses are likely to be greater than this in seasons of poor rainfall.

The surveys and field observations also demonstrated a wide range in the reactions of released varieties to red rot (Trenor and Bailey, 1989). These were confirmed by experiments involving the inoculation of stalks of different varieties growing in field plots. Results from these experiments were closely correlated with the results of the field surveys (Trenor and Bailey, 1989, Anon., 1990). Variety N13 was consistently the most severely damaged followed by NCo376, whereas N12, N14 and N16 were much less severely affected and regarded as resistant (Anon., 1990).

Results from the experiments using inoculation to assess varietal reactions to red rot showed sufficient promise in enabling susceptible genotypes to be detected, for the screening of new genotypes to be introduced as a routine procedure in 1993. Three trials have since been successfully completed. This paper describes the procedures involved and the results obtained.

Materials and methods

Screening procedure

The screening trials are conducted at Mount Edgecombe under rainfed conditions. A mean of 30 advanced new genotypes from the selection sites at Pongola (F), Mtunzini (M), Shakaskraal (W), Mount Edgecombe (E), Umhlanga (L) and the Midlands (H), have been tested annually in the period under review. Standard varieties with known reactions to red rot are included in each trial. Susceptible standards include N13 and NCo376, N12 and N14 are used as intermediate standards and J59/3 is included as the resistant standard variety. The trials are planted in October-November. Each genotype is represented by a 5-6 m row, replicated twice. The trials are arranged in a randomized block design.

The trials are inoculated in July in the year after planting, when the cane is 8-9 months old, according to the method described by Trenor and Bailey (1989). *Glomerella tucumanensis* is isolated from infected field grown cane and cultured on potato dextrose agar at 28°C. Conidia are harvested from the cultures and suspended in sterile water to a concentration of 2 x 10^5/ml. Eighty stalks of each genotype are inoculated (40 per row). Using a sharp bradawl, a hole is made in each stalk at a point approximately one third up from the ground and at the midpoint of an internode. The inoculum, 0,25 ml per stalk, is injected into the hole using a hypodermic syringe fitted with a 13 gauge needle and the holes are subsequently sealed with petroleum jelly. Ten stalks in each row are not inoculated and serve as controls.

Assessment

The trials are assessed 3-4 months after inoculation when the cane is 12 months old. The inoculated and control stalks are split longitudinally and examined. Lesion width, lesion length, number of internodes infected and stalk length and diameter are recorded. These data are used to calculate the per cent volume of the stalk damaged (z) using the following equation:

$$z = (\pi r^2 h)_{lesion} \div (\pi r^2 h)_{stalk} \times 100$$

where r = radius and h = height or length.

The number of internodes damaged and the occurrence of 'white spots' (white-coloured patches of tissue within infected stalks) are also recorded. White spots are considered an important indicator of susceptibility (Prasadarao *et al.*, 1978). The data are analysed and the results and comparisons with the reactions of the standard varieties are used to assign the genotypes under test to one of the following categories of resistance: resistant (rating 2), intermediate (rating 5) and susceptible (rating 8).

Results

A total of 93 advanced selections were tested for resistance to red rot in the trials planted from 1993 to 1995. The number of genotypes tested over this period and the numbers in different resistance categories are shown in Table 1. The inoculations were considered successful and a broad range of ratings was achieved in the three trials. The extent of red rot damage differed from trial to trial, possibly due to the different growing conditions experienced, but the coefficients of variation (CV%) when comparing the reactions of each standard variety in the three different trials, were acceptable. The relative reactions of the standard varieties, when analysed using Analysis of Variance (Statgraphics) were much as expected, with the susceptible standards differing significantly from the resistant (Table 2).

Table 2

Analysis of reactions of standard varieties to red rot infection in three trials. Reactions with a letter in common are not significantly different from one another.

Variety	Mean % volume damaged	LSD 5%*	SD	SE	CV%
J59/3	2,8	a	0,62	0,36	22
N14	3,6	ab	0,90	0,52	18
N12	5,0	b	1,79	1,03	20
N13	8,9	c	0,21	0,12	6
NCo376	10,1	c	0,84	0,48	8

* LSD = 1,9
F-ratio = 30,8

Of the 93 new genotypes tested in the three trials, 44% were rated as resistant (rating 2), 18% were placed in the intermediate category (rating 5) and 38% were regarded as susceptible (rating 8) (Table 1). Those genotypes that were found to be equally or more susceptible than N13 and NCo376, based on the number of internodes and per cent volume damaged, were considered too susceptible for further selection. The mean number of internodes damaged and the mean per cent volume damaged in these genotypes are compared with those of N13 and NCo376 in Table 3. These highly susceptible genotypes constituted 15% of the 93 tested. Genotype 88L790 was the most severely affected of all those tested, with an average of six internodes per stalk infected and 51% stalk damage; dead tops were observed on a number of inoculated stalks of this genotype (Figure 1).

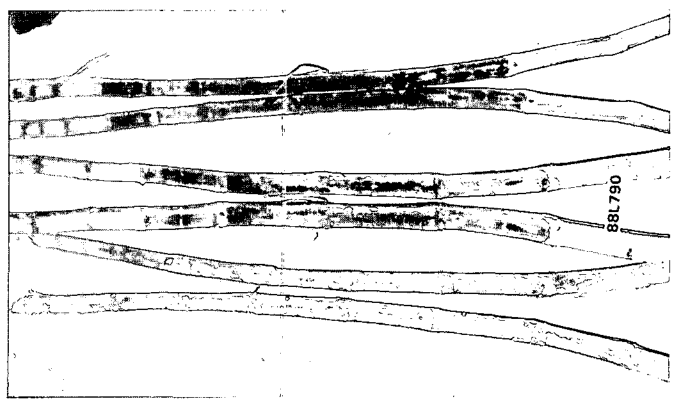

FIGURE 1: Stalks of genotype 88L790 severely damaged by red rot

Table 1

No. of new sugarcane genotypes from different selection sites and standard varieties tested and No. in different categories of resistance to red rot, 1993, 1994 and 1995 (2, resistant; 5, intermediate; 8, susceptible)

Selection and site code		No. of genotypes in different resistance categories											
		No. tested	1993			No. tested	1994			No. tested	1995		
			2	5	8		2	5	8		2	5	8
Pongola	F	4	1	1	2	1	0	0	1	1	0	1	0
Mtunzini	M	11	7	0	4	4	2	0	2	6	1	1	4
Shakaskraal	W	3	3	0	0	5	3	1	1	2	1	1	0
Umhlanga	L	9	6	3	0	8	1	1	6	12	4	4	4
Mt Edgecombe	E	2	2	0	0	11	6	1	4	3	2	0	1
Midlands	H	3	0	1	2	4	12	1	1	4	0	1	3
Total advanced selections		32	19 (59)	5 (16)	8 (25)	33	14 (42)	4 (12)	15 (46)	28	8 (29)	8 (29)	12 (43)
No. standards		7	3	2	2	7	3	1	3	6	3	1	2
Total		39				40				34			

Table 3

New genotypes tested for reaction to red rot and found to be equally or more susceptible than N13 and NCo376 when comparing number of internodes and per cent volume damaged, 1993, 1994 and 1995

1993			1994			1995		
Variety	Internodes	% volume	Variety	Internodes	% volume	Variety	Internodes	% volume
N13	4,3	10,9	N13	2,2	8,5	N13	2,1	7,4
NCo376	5,1	9,5	NCo376	2,9	10,6	NCo376	2,4	9,1
86M1328	4,1	6,1	87L1325	3,6	13,6	88L49	4,0	10,4
81M0842	4,4	7,1	87L1418	3,4	15,6	88L541	3,7	11,2
83F1284	4,6	14,5	86W1448	3,5	18,0 WS	82L1244	3,9	19,7
			84F3097	3,8	18,8	80H75	4,5	25,6
			87L586	4,3	21,3 WS	88L790	5,7	51,4 WS*

WS = white spots
* = dead tops

Twenty nine of the 93 new genotypes tested were from the Umhlanga selection site. Ten of these (35%) were rated as susceptible and seven (24%) were considered too susceptible for further selection. This was the highest proportion of highly susceptible genotypes from all sites. There was also a high proportion (48%) of susceptible genotypes from the Mtunzini site, and 14% from this site were considered too susceptible for further selection. A high proportion (69%) of the Mount Edgecombe selections were rated as resistant or moderately resistant.

There was some variation in the percentages of genotypes in each category of resistance in the three different trials (Figure 2, Table 1). Of the 32 new genotypes tested in the first screening trial in 1993, 59% were rated as resistant, 16% as moderately resistant and 25% as susceptible. It was recommended that three of the genotypes tested (9%) be discarded because of high susceptibility. Of the 33 genotypes tested in 1994, 42% were resistant, 12% intermediate and 46% susceptible and six (18%) were considered too susceptible for further selection. A high percentage (43%) of the 28 genotypes tested in 1995 were found to be susceptible. Equal numbers (29%) of genotypes tested in this trial were found to be resistant or intermediate in reaction and five (18%) were considered too susceptible for further selection (Table 1, Figure 2).

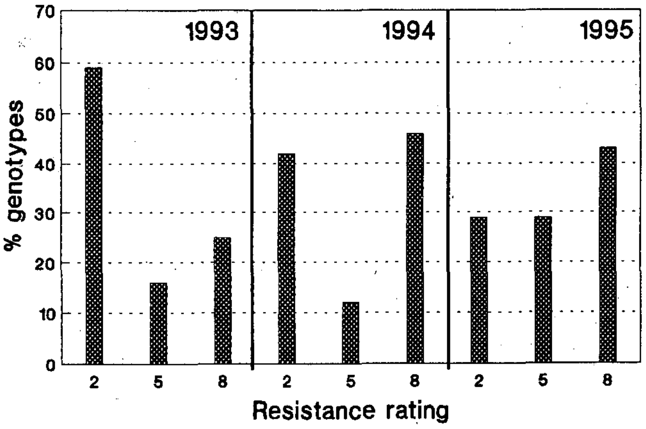

FIGURE 2: Percentages of new sugarcane genotypes in different categories of resistance to red rot, 1993, 1994 and 1995 (2, resistant; 5, intermediate; 8, susceptible)

Discussion

Although red rot is a 'low profile' disease and is usually not regarded by growers as important as ratoon stunting disease, smut and mosaic in the South African sugar industry, it can cause significant reductions in yield if climatic conditions favour its development. It is therefore important to ascertain which genotypes are highly susceptible to the disease so that they can be discarded from the selection process. Since the symptoms are usually not easily recognised in the field, susceptible genotypes might proceed to the stage of release unless identified. The artificial inoculation of standing stalks has proved to be a useful method of determining the reactions of new genotypes to the pathogen.

Although screening for red rot resistance is now a routine procedure, a number of aspects require further investigation and improvement. The current method of interpreting results needs to be compared with the mathematical model developed by Prasadarao *et al.* (1978). Collection of trial data for the mathematical model would be time consuming but the model may simplify the interpretation and improve the reliability of the results.

Pathogenic variability in the red rot pathogen has been reported in different regions of India (Waraitch, 1984). Most genotypes selected at Mount Edgecombe were found to be resistant or moderately resistant to red rot and no genotypes were too susceptible for further selection. The trials were planted at Mount Edgecombe, and *G. tucumanensis* was isolated from sugarcane growing at the same location. This may indicate that genotypes selected at this site might be resistant to a specific strain of *G. tucumanensis* occurring at Mount Edgecombe. Genotypes such as 88L790 might have escaped severe infection during the course of selection at other locations for the same reason but were susceptible to the Mount Edgecombe isolate. The possibility of variation in *G. tucumanensis* in South Africa requires investigation. The use of a mixed inoculum, prepared from a number of isolates of the pathogen collected from different localities, seems a worthwhile precaution.

Although the ranking of the standard varieties was much as expected in the three trials, the marked effect of growing conditions on the development of red rot in inoculated stalks presents some problems in interpreting the results. Abbott (1956) reported that environmental factors could so favour the development of *G. tucumanensis* and adversely affect the sugarcane plant that the balance is tipped in favour of the pathogen, resulting in severe damage to varieties that would normally be considered resistant. The inclusion of standard varieties in each trial partly compensates for this seasonal variability. However, the repeatability of results with previously untested genotypes requires investigation. This can be done by re-inoculating a completed trial and comparing results obtained in different seasons.

The inoculation and assessment of red rot screening trials is time consuming. Hence, only a limited number of advanced selections can be tested each year. Unless new methods can be found, screening will remain limited to a small number of advanced selections. If the results of red rot trials prove to be repeatable, the trials will continue to provide useful information on the reaction of commercial varieties and advanced selections to infection by red rot.

Conclusions

A practical method of assessing the reactions of advanced, new sugarcane genotypes to infection by red rot has been developed and is established as a routine operation during variety selection. Fifteen per cent of the new genotypes tested in the period 1993 to 1995 were regarded as highly susceptible and unsuitable for release. A different method of evaluating resistance to red rot is necessary before larger numbers of genotypes can be screened.

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