SYMPTOM EXPRESSION OF SUGARCANE MOSAIC VIRUS (SCMV) AND ASSOCIATED EFFECTS ON SUGARCANE YIELD

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Abstract

Plots of sugarcane varieties NCo376 (susceptible) and N12 (moderately resistant) were established at Mount Edgecombe in 1985. SCMV is rare in this locality and the activity of vector aphids is known to be low. The seedcane used for both varieties was either apparently healthy (from symptomless, nursery-grown plants at Mount Edgecombe) or severely infected. In the plots planted with infected seedcane, the number of shoots of NCo376 with visually recognisable symptoms declined from 86% to 24% from the plant crop to the sixth ratoon crop (mean 53%), and in N12 from 69% to 7% (mean 34%). Despite the apparent recovery, cane and sucrose yields of both varieties remained severely depressed throughout the trial period compared with the initially healthy plots: the mean reduction in cane yield in all crops was 22% in NCo376 and 16% in N12. The initially healthy plots of both varieties remained virtually free of visual symptoms throughout the trial period. Serological tests for SCMV, using protein blots and ELISA, detected SCMV in many symptomless plants in the sixth ratoon crop in the initially severely infested plots where apparent recovery had occurred: the virus was detected in 77% of all shoots of NCo376 (24% visual symptoms) and 52% in N12 (7% visual symptoms). The tests also demonstrated SCMV infection in the sixth ratoon in the initially healthy plots: the virus was detected in 21% and 6% of the symptomless shoots of NCo376 and N12 respectively in these plots. Virus assays indicated that the mean concentration of virus particles in infected host tissue was higher in NCo376 than in N12, and higher in shoots which expressed symptoms than in those that did not in both varieties.

Introduction

Sugarcane mosaic virus (SCMV) in South Africa has fluctuated in importance since before 1920. The disease was probably introduced in varieties imported from Argentine in 1914 (Storey, 1924), and rapidly became common in the susceptible varieties then being grown. It became common in the susceptible varieties NCo376 and NCo293 in the cooler areas of cane production in Natal from the 1980s (Bailey and Fox, 1980). In recent years, good progress in the breeding and selection for resistance to SCMV has been made, and most varieties currently grown in areas where mosaic was formerly a problem are acceptably resistant, as assessed by the expression of visual symptoms.

Most screening of new sugarcane genotypes for resistance to diseases, and in particular viral diseases such as SCMV, is done on the basis of symptom expression in plants infected either naturally or by inoculation. This would be adequate if it were established that a viral infection always gives rise to typical, easily recognisable symptoms under any climatic and geographical circumstances. However, it has been established that this is not the case with SCMV. Various strains of the virus occur and these differ in their ability to infect different varieties, and in virulence and symptom expression (Kondaiah and Nayudu, 1984). Reports indicate that it is not uncommon that plants lose visible infection symptoms or, in some varieties only show inconspicuous symptoms after infection has been well established in a crop (Anon., 1956).

Reports of crop loss caused by SCMV infection in sugarcane vary with the virus strain involved, variety, growing conditions and agronomic practices. Reductions in yield of 30-50% in susceptible varieties have been reported (Villalon, 1980; Bailey and Fox, 1980). In India, approximately 1% cane yield was reported lost for every 10% increase in visible symptoms (Rishi et al., 1975). In South Africa, it has been estimated that the reduction in yield in varieties NCo376 and N12 varies from 0,3 to 0,5 ton cane/ha for every 1% increase in stalks with visible symptoms (Bailey and Fox, 1987).

This paper describes the progressive loss of visual symptoms of SCMV infection with continued ratooning, although yield loss remained at high levels.

Materials and Methods

The field trial reported here was planted at Mount Edgecombe, Natal, in 1985. Plots of sugarcane varieties NCo376 (highly susceptible to infection with SCMV) and N12 (more resistant) were established using a replicated block design. The seedcane used for both varieties was either apparently healthy (from symptomless, nursery-grown plants at Mount Edgecombe) or severely infected (stalks from plants exhibiting visual symptoms in fields of commercial cane in areas where SCMV was common). SCMV is rare at Mount Edgecombe and the activity of vector aphids is known to be low (Anon., 1987).

The plots were harvested on a 14 to 16 month cropping cycle up to the sixth ratoon crop. The various components of yield were recorded and in each crop inspections for mosaic symptoms were made.

The technology to test serologically for SCMV on a large scale has only recently been introduced at SASEX. Only plants from the sixth ratoon crop were tested for the presence of SCMV using such a technique.

The third leaves from 100 randomly selected plants from each treatment were collected for virus sampling. The leaves were ground separately in phosphate buffered saline with 0,02% bovine serum albumin (PBS-BSA) and tested by indirect enzyme linked immunosorbent assay (ELISA) against two different SCMV antisera. The standard ELISA protocol and buffers were used (Clark and Adams, 1977). The plates were read by a scanner at 405 nm and all reactions two times higher than background were taken to be positive. In cases where ambiguous results were obtained, samples from the same leaf were isolated for total protein. The proteins were then separated on a denaturing SDS-PAGE gel, transfered to nitrocellulose and probed with monospecific antibodies against SCMV. In some cases no visible infection could be found for the plants in a specific category, and the sample sizes were reduced in such cases. Data were analysed with a randomised factorial design, and the Tukey test for significant differences in means was used.

Results

It was found that, in the plots planted with infected seedcane, the number of shoots of NCo376 with visually recognisable symptoms declined from 86% to 24% from the plant to the sixth ratoon crop (mean 53%), and in N12 from 69% to 7% (mean 34%). The cane and sucrose yields of both varieties in the plots planted with infected seedcane remained severely depressed compared with the initially healthy plots throughout the trial period (Table 1). The mean reduction in cane yield in all crops was 22% in NCo376 and 16% in N12 throughout the trial period, the initially healthy plots of both varieties remained virtually free of visual symptoms throughout the trial period.

Table 1

Yield components of and visual symptoms on NCo376 and N12 planted with healthy and SCMV - infected seed material (means of 7 crops).

Source	Cane (t/ha)	ERS (t/ha)	Stalks/ha × 10^{-3}	Stalks with symptoms
NCo376(H)	113.3	15.0	178	0.1
NCo376(D)	88.2	11.8	145	52.6
N12(H)	100.3	13.2	185	0.1
N12(D)	84.4	11.1	160	34.3

H = healthy
D = diseased

Throughout the trial period the difference in cane yield between 'healthy' and 'infested' plots (Figure 1) and the difference in estimated recoverable sucrose (Figure 2) remained about constant. From the second ratoon onwards, the stalk population (Figure 3) of NCo376 was significantly lower, and this is the only measured component where significant reductions occurred.

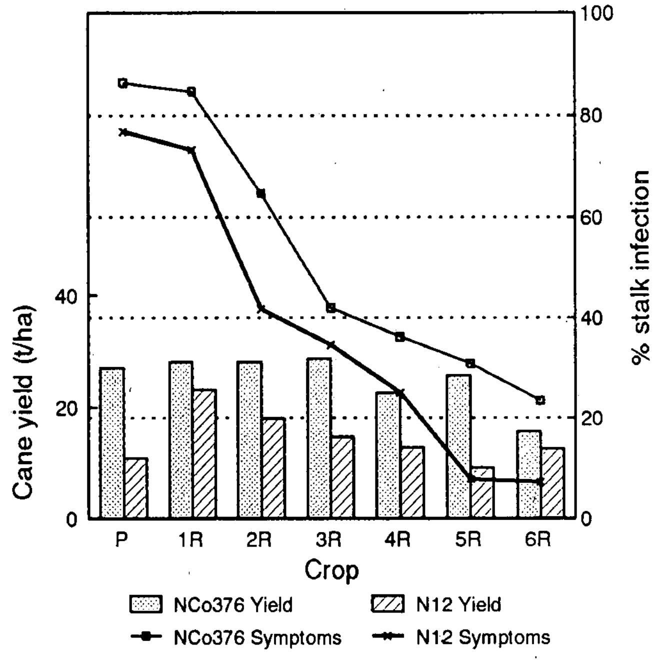

FIGURE 1 Visible symptoms of SCMV infection and the associated difference in cane yield between plots planted with healthy and infected seed of varieties NCo376 and N12 (7 crops).

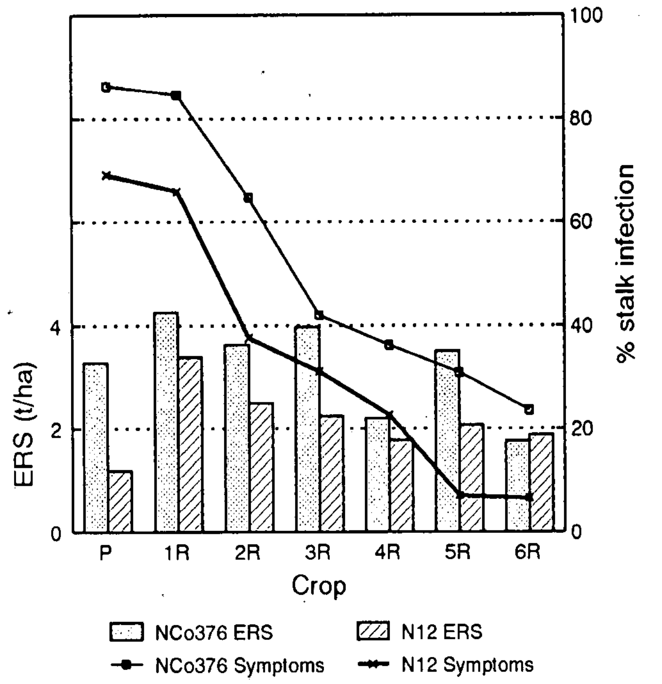

FIGURE 2 Visible symptoms of SCMV infection and the associated difference in recoverable sucrose (t/ha) between plots planted with healthy and infected seed of varieties NCo376 and N12 (7 crops).

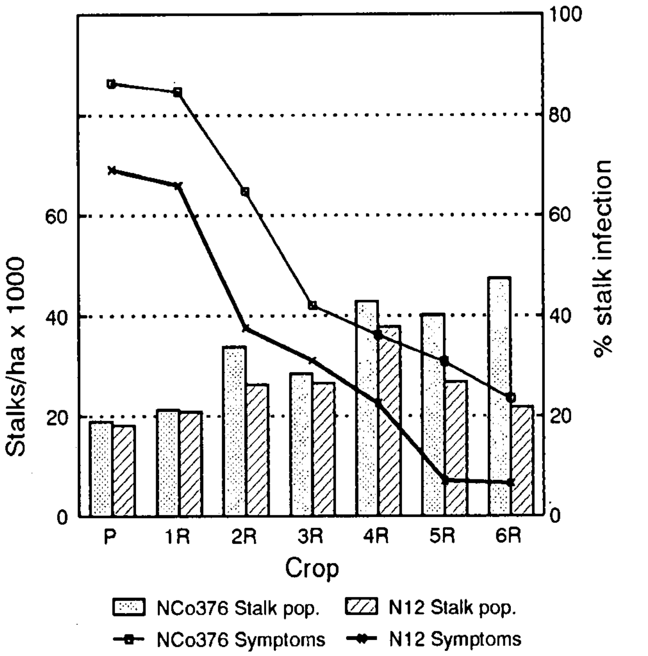

FIGURE 3 Visible symptoms of SCMV infection and the associated difference in stalk population (thousand/ha) between plots planted with healthy and infected seed of varieties NCo376 and N12 (7 crops).

In the sixth ratoon crop, serological tests using western blots and ELISA detected SCMV in many symptomless plants in the initially severely infested plots where apparent recovery had occurred. In NCo376, SCMV was detected in 77% of the shoots, whereas only 24% of the stalks had visual symptoms (Figure 4a). In N12, SCMV was detected in 52% of the stalks whereas only 7% had visual symptoms (Figure 4b).

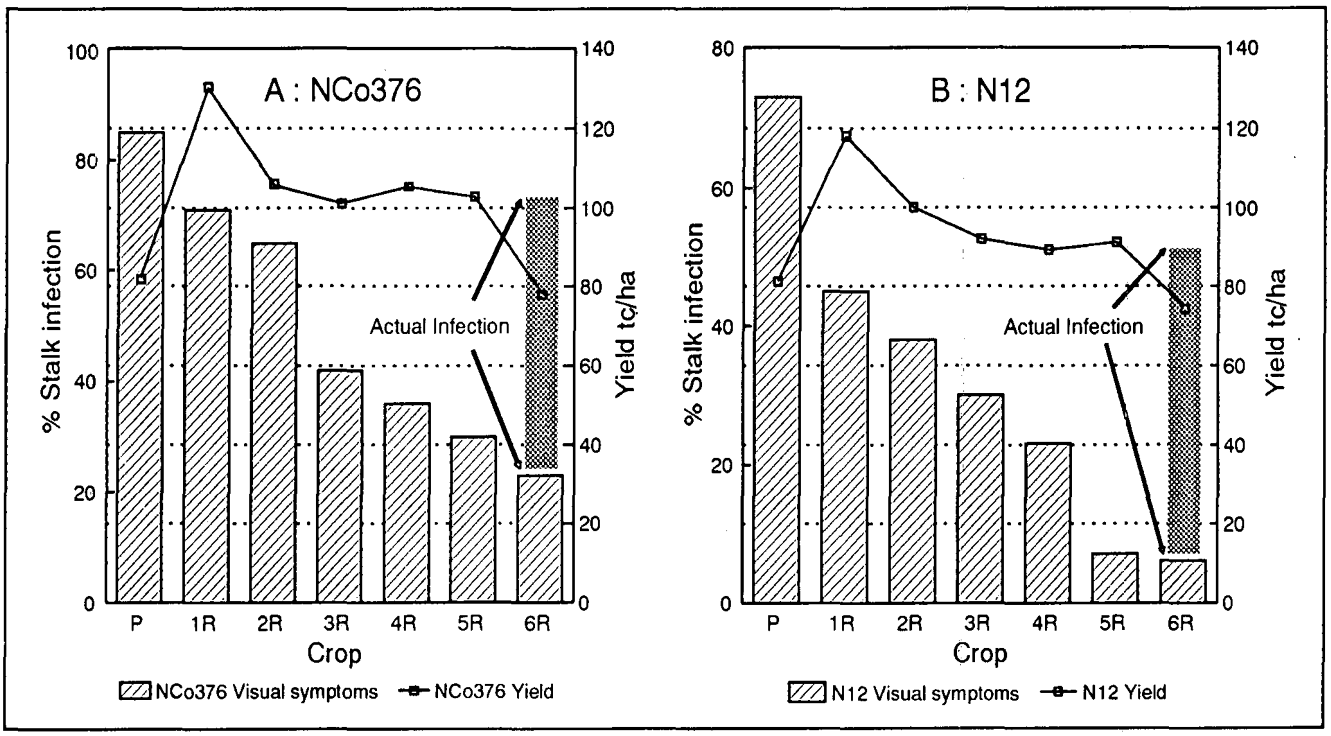

FIGURE 4 Visual and actual SCMV infection and cane yield (t/ha) in a) NCo376 and b) N12.

The tests also demonstrated SCMV infection in the sixth ratoon in the initially healthy plots: the virus was detected in 21% and 6% of the symptomless shoots of NCo376 and N12 respectively. Assays of virus concentration indicated that the mean concentration of virus particles in infected host tissue was higher in NCo376 than in N12, and in both varieties it was higher in shoots which expressed symptoms than in those that did not (Figure 5).

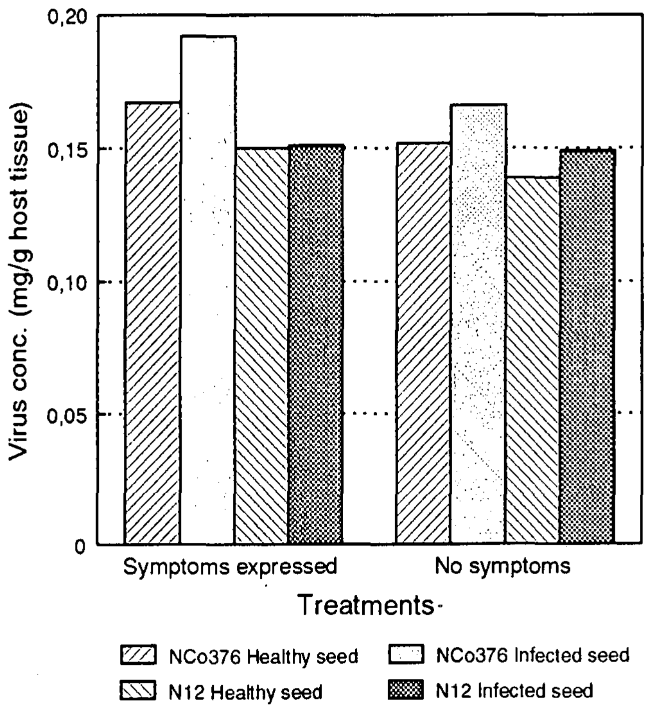

FIGURE 5 Concentration of SCMV virus in isolates obtained from NCo376 and N12, both planted with and without symptoms.

Discussion

Although further work is needed, these findings show that the expression of visual symptoms may not be a good measure of the reaction of sugarcane varieties to SCMV. New, highly sensitive techniques which can be applied to large numbers of samples are now available to test for viral infections.

During the serological testing of the trial material, samples of variety N11 (highly resistant to SCMV) grown nearby were also tested. The recovery of viral particles from this apparently resistant variety indicates by SCMV that visual symptom expression may be unreliable for detecting infection by SCMV.

Several of the known viral diseases of sugarcane cause little or no obvious symptoms, but cannot be said to have no effect on yield, as this experiment on SCMV illustrates. When the high actual infection levels are considered, the sustained reduction in yields can be adequately explained.

The assays of virus concentration indicated that the mean concentration of virus particles in infected host tissue was higher in NCo376 than in N12, that in both varieties it was higher in shoots which expressed symptoms than in those that did not.

Tests to compare visual symptoms with serologically determined virus in routine screening trials will start shortly. There is the need to determine also whether virus presence or virus concentration can be directly linked to yield reduction.

Fraser (1992) reports that it has been illustrated that various pathways exist for disease resistance in plants, and that in some instances a virus infected plant might show no obvious symptoms, but still have high concentrations of virus in it, probably causing yield loss.

Conclusions

Visual symptoms of SCMV in NCo376 and N12 declined steadily from the plant crop to the sixth ratoon crop in an area where little spread of the virus occurred. Despite the loss of symptoms, serious reductions in yield were maintained. It is apparent that in this trial, infection by SCMV without expression of visual symptoms was a major factor contributing to yield losses. In predicting varietal reactions to SCMV, there is a need to determine the accuracy of current screening methods based on the recognition of symptoms.

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