USE OF VARIETIES TO MINIMISE LOSSES FROM SUGARCANE DISEASES IN SOUTH AFRICA

R S RUTHERFORD, S A MCFARLANE, T VAN ANTWERPEN
and K MCFARLANE

South African Sugar Association Experiment Station, P/Bag X02,
Mount Edgecombe, 4300, South Africa
E-mail: *rutherford@sugar.org.za*

Abstract

The current low incidence of sugarcane diseases in the South African sugar industry has been hard-won. This achievement is due largely to the selection and release of resistant varieties. Consequently, current estimates of crop loss due to smut and mosaic indicate reductions in yield of only 0.2% in total, equivalent to R7 million per annum. In the absence of an RSD variety resistance screening method, the incidence of this disease has been reduced via the use of RSD-free seedcane and the employment of field hygiene measures. Loss due to RSD is estimated at 0.3% of yield, equivalent to R10 million per annum. The continued control of other important sugarcane pathogens is based on selecting and releasing varieties with satisfactory resistance. The benefit of growing sugarcane varieties that minimise losses from diseases can be demonstrated by quantifying the effect of diseases on susceptible varieties.

Keywords: sugarcane, yield loss, disease, smut, mosaic, rust, RSD

Introduction

The continued control of important sugarcane pathogens in South Africa is based on selecting and releasing varieties with satisfactory resistance. Procedures for the screening of new varieties for disease resistance in the plant breeding programme have been in place for more than 25 years. As consequences of the successful selection of resistant genotypes and an appropriate variety release strategy, smut and mosaic are no longer major threats to production for most growers. However, the pathogens that cause these diseases, as well as others, are always present in the industry. The benefit of continuing to breed and grow sugarcane varieties that minimise losses from diseases can be demonstrated by quantifying the effect of diseases on susceptible varieties.

Ratoon stunting disease (RSD)

To date, no rapid practical test to assess variety reactions to ratoon stunting disease (RSD) has been applied to the plant breeding selection programme, due to the absence of obvious external symptoms. Disease levels have been reduced through the adoption of appropriate management practices, such as fallow periods or green manuring, the use of hot water treated, RSD-free seedcane, and frequent disinfection of cane knives. The RSD diagnostic service introduced at the South African Sugar Association Experiment Station (SASEX) in the late 1970s has also played a role in reducing levels of RSD by making growers more aware of the disease, and identifying infected seed sources and commercial fields. Information on variety resistance has been limited to assessments of yield loss in specially planted trials (Bailey and Bechet, 1986; 1995) (Figures 1 and 2).

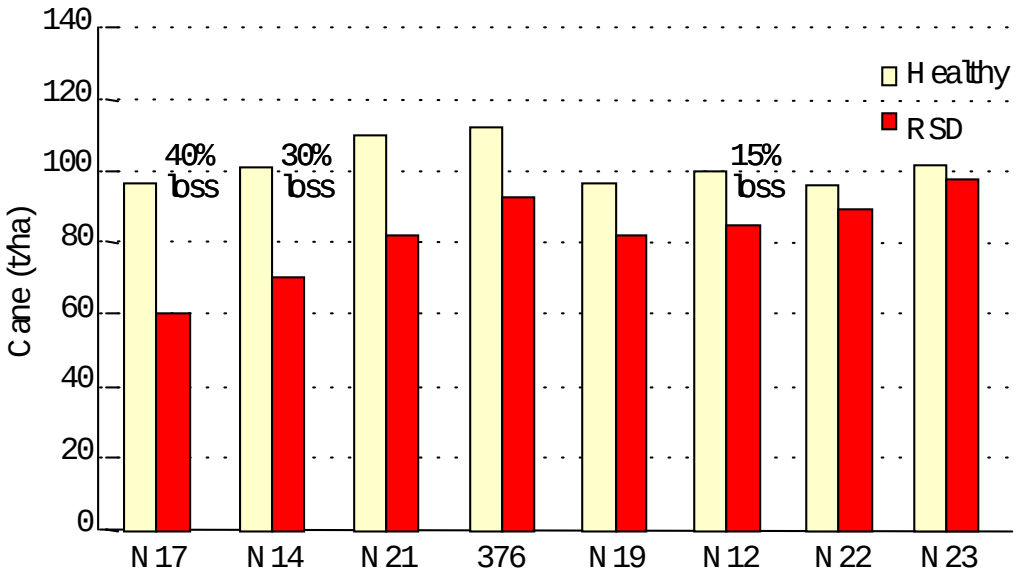

Figure 1. Yield loss due to RSD in a rainfed trial.

More recently, a correlation has been found between yield loss and the extent of colonisation of the vascular bundles by the RSD bacterium, *Leifsonia xyli* subsp *xyli*. This method will allow for more rapid screening of resistance to infection (Figure 2) (McFarlane, 2002)

.

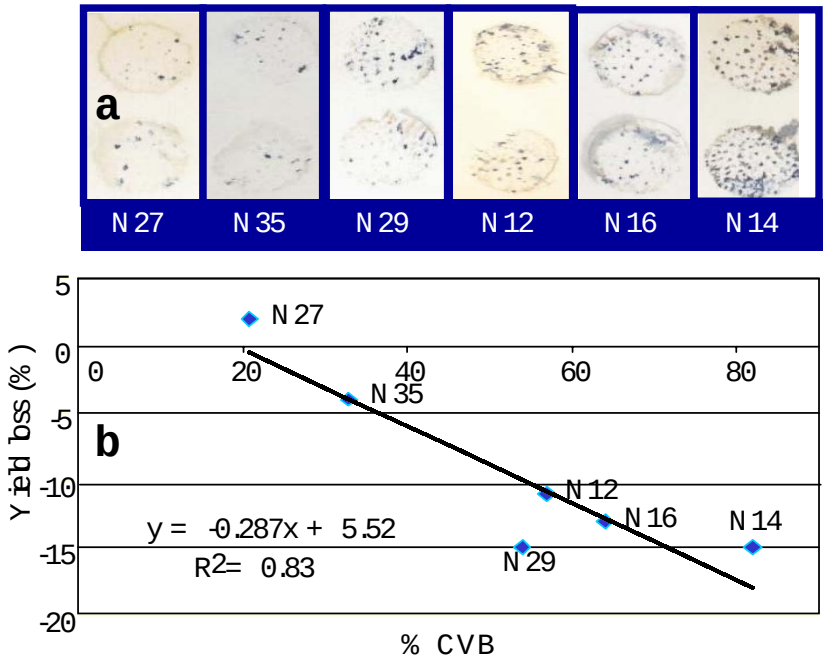

Figure 2a. Tissue blot immunoassay showing vascular bundles colonised by the RSD bacterium. 2b. Relationship between percentage colonised vascular bundles (% CVB) and yield loss.

The data in Figures 1 and 2 indicate that varieties N17, N14 and N29 are particularly susceptible to RSD, suffering up to a 40% reduction in yield. It must be emphasised that a combination of drought and RSD can greatly increase yield loss in susceptible varieties (Anon, 1980a).

Varieties N12, N23, N27 and N35 appear more resistant, and N22 appears tolerant in that, although it is easily infected (Figure 3), it does not suffer significant yield loss (Figure 1). Data for all current commercial varieties will become available in due course.

It is important to note that RSD levels increase through ratoons. Data from some fields of NCo376 and N22 suggest that RSD infection can increase from low levels at planting, to 100% of stalks between the third and fifth ratoon (Figure 3) ([1]unpublished results).

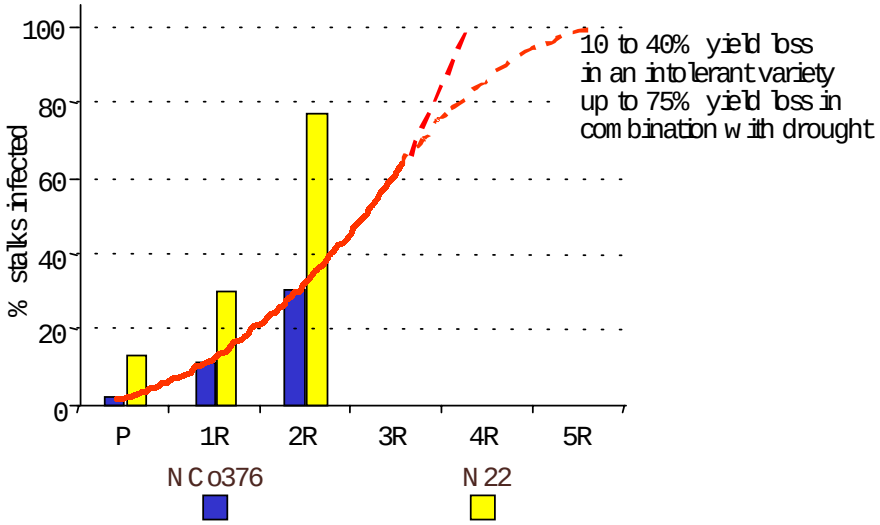

Figure 3. Spread of RSD in varieties NCo376 and N22 under irrigation (P to 2R). Curved line represents extrapolation of disease progression in NCo376.

Smut

The successful control of smut, caused by the fungus *Ustilago scitaminea*, has been due mainly to the selection and release of new, resistant varieties as replacements for old susceptible varieties since the early 1980s (Bailey *et al*., 1994). In the years preceding the selection and release of resistant varieties, reliance on susceptible varieties, such as NCo310 and NCo376, led to a rapid increase in the incidence of smut in the warmer, irrigated areas of Pongola and the Mpumalanga lowveld. Such was the dependence of the whole industry on susceptible varieties, that smut became common in other regions as well, and particularly in Umfolozi and Zululand North (Bailey *et al*., 1994).

A simple mathematical model can be used to predict the risk of smut again becoming problematic on a regional basis, if susceptible varieties are grown. The smut-risk model was developed using data for naturally infected NCo376 on the SASEX Pongola Research Station, and the corresponding meteorological data for the period 1978 to 1999. Smut incidence in first ratoon NCo376 ranged between 3 000 and 33 000 whips per hectare during this period (average of 14 000 whips per hectare). This variation in smut incidence can be partially explained by an equation combining rainfall and temperature for May through August of each year. Greater incidence of smut is associated with drier and warmer winters. Applying the model to long term mean meteorological data from the various regions in the sugar industry gives an indication as to which regions are more or less at risk (Figure 4).

[1] SA McFarlane and D Subramoney, Pathology Department, SASEX, Mount Edgecombe.

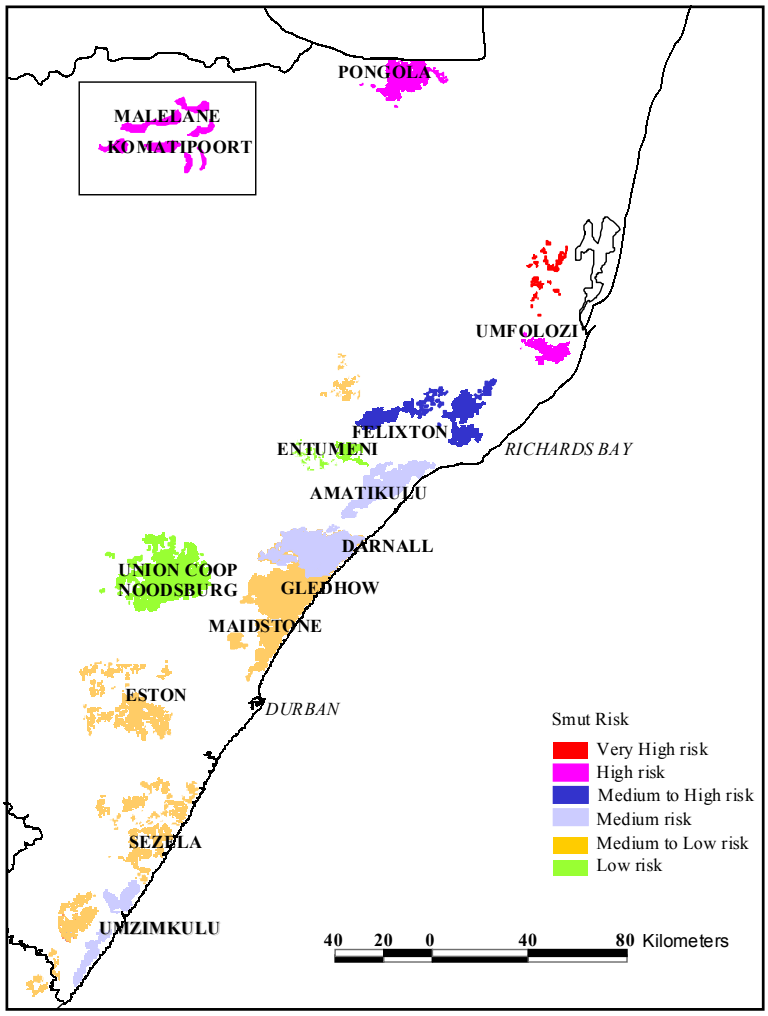

Figure 4. Smut risk map of the South African sugar industry.

The model is intended for use as a tool in the SASEX variety release decision-making process. This process incorporates the concept of 'regional release', which permits the release of outstanding varieties with susceptibility to one major disease in areas where that disease is thought not to constitute a risk. The release of smut susceptible varieties may now be necessary in certain areas in an effort to combat eldana, since varieties highly resistant to eldana tend to be smut susceptible. An example of an eldana resistant variety suitable for areas of low smut risk is N39.

Yield loss due to different levels of smut in NCo376 has been estimated in fungicide trials (Bailey, 1979a, 1983). Figure 5 summarises the results of several such trials. The gradient of each linear regression line represents tons cane lost per 1 000 smut whips per hectare. Extrapolating the line to the Y-axis gives an estimate of the yield that would have been attained in the absence of smut.

These trials suggest that yield loss can vary between 0.26 and 1.9 tons cane per 1 000 whips per hectare. The data also suggests that, under high yielding conditions (defined by the zero smut extrapolation), yield loss per 1 000 whips per hectare is not as great as under low yielding conditions (Figure 6).

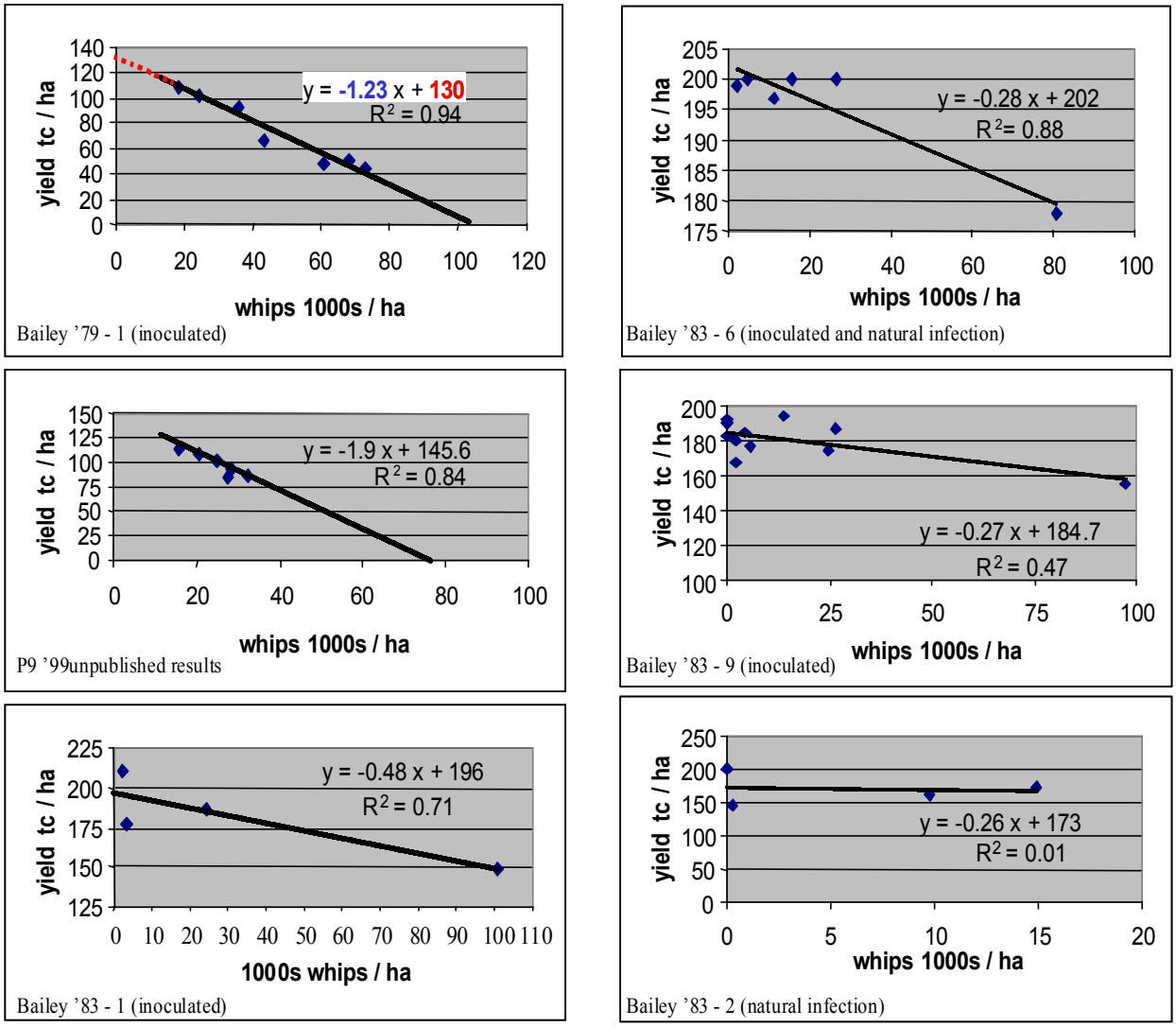

Figure 5. Yield loss due to smut in first ratoon NCo376 in six separate fungicide trials (Bailey 1979a, 1983 and unpublished data).

For example, a grower expecting 160 tons cane per hectare may lose 1 ton for every 1 000 whips per hectare. In an average first ratoon at Pongola, 14 000 whips per hectare would be expected to result in a yield loss of 14 tons cane per hectare (approximately 10%). A grower expecting 110 tons cane per hectare may lose 2 tonnes for every 1 000 whips per hectare. In a worst case scenario of 33 000 whips per hectare, a yield loss of 67 tons cane per hectare (60%) might be expected.

It is important to note that smut levels increase through ratoons. An exponential increase in whips per hectare might be expected. In a susceptible variety such as NCo376, as much as 75% yield loss in the third ratoon could be possible under typical conditions found in the Pongola region (Figure 7).

Most varieties released since 1980 are more resistant than NCo376 (Figure 8). Whereas more than 95% of the all-region crush in 1978/79 was from highly smut susceptible varieties, less than 15% of the 2001/02 all-region crop was comprised of these varieties (McFarlane and McFarlane, 2002).

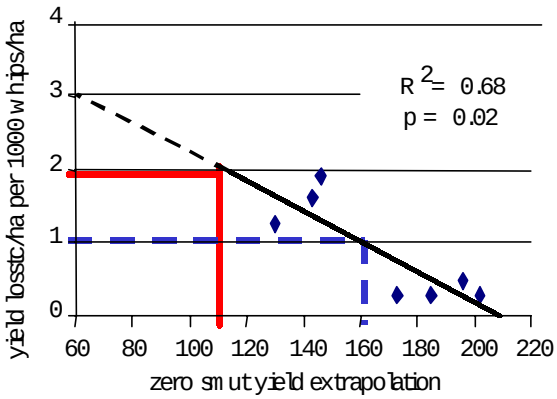

Figure 6. Relationship between potential yield (zero smut extrapolation) and yield loss per 1 000 whips/hectare (gradients and extrapolations of regression lines from Figure 5).

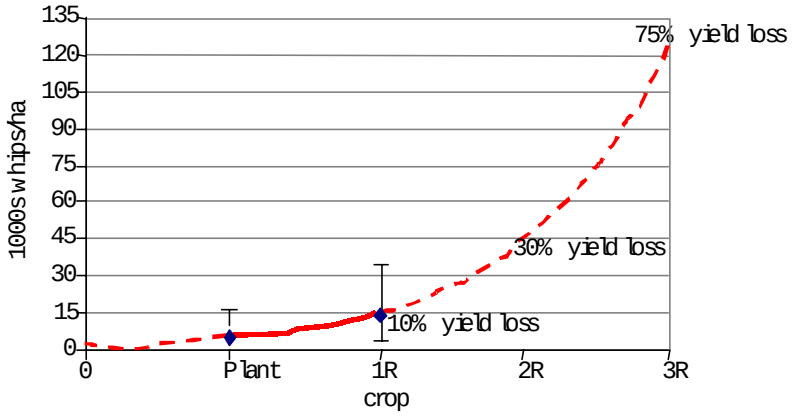

Figure 7. In NCo376 smut levels increase with successive ratoons. 1000s whips/ha in P and 1R NCo376 are average levels of natural infection for the period 1978-1999 at Pongola (bars show range for the period).

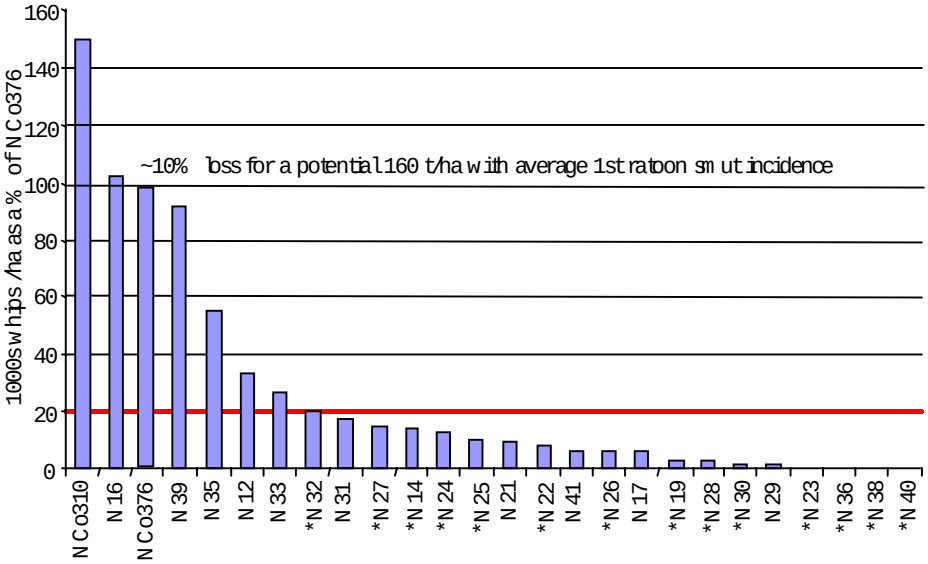

Figure 8. Resistance of varieties to smut relative to NCo376. Varieties having less than 20% of the first ratoon whips per hectare level expressed by NCo376, and denoted by an asterisk*, are suitable for planting in areas where smut is a medium to high risk.

Mosaic

Variety NCo376 represented 70% of the cane crushed in the industry in 1978/79 and variety NCo293 was the second most widely grown variety in the Natal Midlands (50% of cane crushed at the Union Co-op and Noodsberg mills in 1978/79) (Bailey *et al*., 1994). Both varieties are susceptible to sugarcane mosaic virus (SCMV), as well as to smut.

Reports of crop loss due to mosaic vary with variety, growing conditions and agronomic practices. In South Africa, mosaic in NCo376 can cause a loss in yield of 0.3 to 0.5% for every 1% stalks infected (Fox and Bailey, 1987; Cronje *et al.,* 1994). In the Midlands, NCo376 can be over 90% infected by the first ratoon, particularly where fields were planted or harvested from October to the end of January (Bailey and Fox, 1980). The mosaic virus is transmitted mainly by the aphids *Hysteroneura setariae* and *Rhopalosiphum maidis*, and aphid populations peak in summer when the cane is young and susceptible to attack.

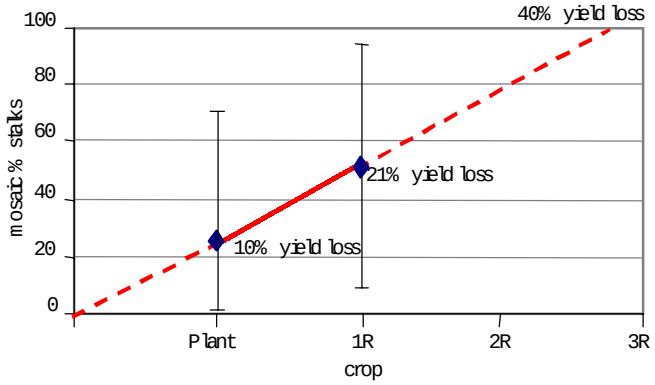

Figure 9. In NCo376 mosaic levels increase with successive ratoons. Percentage stalks with mosaic in P and 1R NCo376 are average levels of natural infection for the period 1988-2000 at Eston (bars show range for the period).

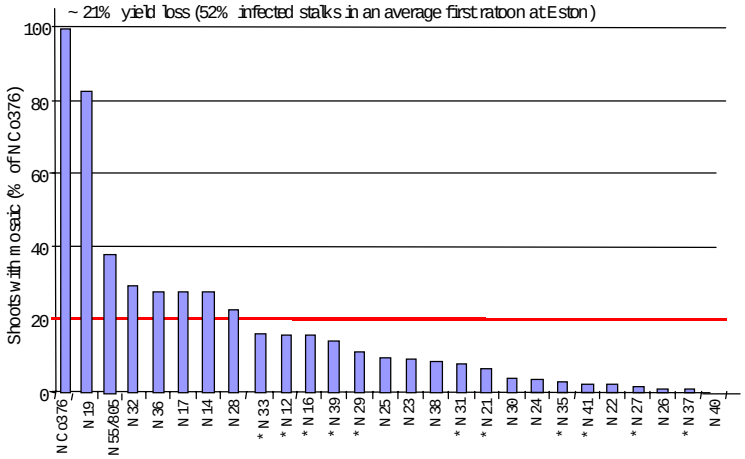

Figure 10. Resistance of varieties to mosaic relative to NCo376. Varieties having less than 20% of the first ratoon infection level expressed by NCo376, and denoted by an asterisk*, are suitable for planting in areas where mosaic is a problem (Midlands and South Coast).

The resistance of the newer varieties to mosaic compared with NCo376 has improved markedly (Figure 10). The crop in the areas where mosaic was formerly most common is now composed almost entirely of resistant and intermediate varieties, predominantly N12 and N16.

Rust

Outbreaks of brown (common) rust, caused by the fungus *Puccinia melanocephala,* are largely dependent on cool and damp environmental conditions. A yield loss of around 20% has been reported for N55/805 in a fungicide trial (Anon, 1980b). N55/805, the third most widely grown variety in 1978/79 (11% of cane crushed in the rainfed areas), was often severely damaged by rust. Of current varieties, N29 is the most susceptible.

Concluding Remarks

Estimates of crop loss in susceptible varieties range from 40% for RSD and mosaic, when 100% of stalks are infected, to around 75% for smut when 100% of stools are infected (Table 1).

Table 1. Expected yield loss where susceptible varieties are grown in areas where a disease is prevalent and other control measures are not employed.

Disease	Disease level	Yield loss	Comments
Smut	100% of stools	~75%	Build up over ratoons
RSD	100% of stalks	~40%	
Mosaic	100% of stalks	~40%	
Rust	Severe	~20%	Strong environmental influence

Diseases can rapidly build up to levels that severely decrease yields. By using a combination of resistant varieties and management practices designed to limit the impact of diseases, the incidence of infection has been reduced to a relatively low level. Based on recent disease incidence data, industry-wide losses can be estimated and compared with the situation of 1984/85 (Table 2). Just six years earlier than this, combined yield loss due to RSD, smut and mosaic was estimated to be 5.7% (Bailey, 1979b). A return to that level today would probably result in annual losses exceeding R200 million.

Table 2. Estimates of industry-wide losses due to diseases in 1984/85 season (Bailey and Fox, 1984; Bailey et al., 1994) and in the 2000/01 (Anon, 2001) (1984/85 losses adjusted to current Rand values).

Disease	Disease incidence 1984/85			Disease incidence 2000/01		
	Mean disease level	Yield loss	Value of loss	Mean disease level	Yield loss	Value of loss
RSD	10% stalks	3.0%	R100 m	1% stalks	0.3%	R10 m
Mosaic	1% stalks	0.4%	R 13 m	0.3% stalks	0.12%	R 4 m
Smut	850 whips/ha	1.5%	R 50 m	50 whips/ha	0.1%	R 3 m
			R163 m			R17 m

NB. Disease levels are means for the whole industry.

The concept of 'regional release', which permits the release of outstanding varieties with susceptibility to one major disease in areas where that disease does not constitute a serious risk, continues to be applied.

N19, which is susceptible to mosaic, was released for the warmer areas where mosaic was considered unlikely to become a problem.

However, recent experience in Mpumalanga highlights the need to manage disease susceptible varieties correctly, even in areas considered to be low risk for the disease. An integrated control programme, underpinned by the use of healthy seedcane, should be used in all areas in order to maintain low levels of disease incidence.

REFERENCES

Anon (1980a). RSD and drought. *S Afr Sug Ass Expt Stn Annual Report* 1980/81. p 70.

Anon (1980b). Rust in variety N55/805. *S Afr Sug Ass Expt Stn Annual Report* 1980/81. p 71.

Anon (2001). Pest and Disease Report for the Year 2000/2001. Internal Report, South African Sugar Association Experiment Station, Mount Edgecombe, South Africa.

Bailey RA (1979a). Possibilities for the control of sugarcane smut (*Ustilago scitaminea*) with fungicides. *Proc S Afr Sug Technol Ass* 53: 137-142.

Bailey RA (1979b). An assessment of the status of sugarcane diseases in South Africa. *Proc S Afr Sug Technol Ass* 53: 120-138.

Bailey RA (1983). The effect of soil and seedcane applications of Triadimefon on the incidence of sugarcane smut (*Ustilago scitaminea*). *Proc S Afr Sug Technol Ass* 57: 99-104.

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: 204-210.

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

Bailey RA and Fox PH (1980). The susceptibility of varieties to mosaic and the effect of planting date on mosaic incidence in South Africa. *Proc S Afr Sug Technol Ass* 54: 1-7.

Bailey RA and Fox PH (1984). A large scale diagnostic service for Ratoon Stunting Disease of sugarcane. *Proc S Afr Sug Technol Ass* 58: 204-210.

Bailey RA, Bechet GR and Tucker AB (1994). Progress towards disease control in the South African sugar industry. *Proc S Afr Sug Technol Ass* 68: 3-7.

Cronje CPR, Bechet GR and Bailey RA (1994). Symptom expression of sugarcane mosaic virus (SCMV) and associated effects on sugarcane yield. *Proc S Afr Sug Technol Ass* 68: 8-11.

Fox PH and Bailey RA (1987). Preliminary report on the effect of sugarcane mosaic virus on the yield of sugarcane varieties NCo376 and N12. *Proc S Afr Sug Technol Ass* 61: 1-4.

McFarlane SA (2002). The relationship between extent of colonisation by *Leifsonia xyli* subsp *xyli* and yield loss in different sugarcane varieties. *Proc S Afr Sug Technol Ass* 76: 281-284.

McFarlane K and McFarlane SA (2002). Improvements in the smut screening programme at the Pongola Research Station. *Proc S Afr Sug Technol Ass* 76: 285-288.