PROGRESS TOWARDS DISEASE CONTROL IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

The current status of sugarcane diseases in the South African sugar industry is described and compared with that of the late 1970s and early 1980s. Substantial progress has been made in reducing the incidence of the common diseases smut and mosaic, which were formerly increasing in economic significance over wide areas and were perceived as strategic threats to production. The hazard once presented by leaf scald, which is endemic in the warmer, irrigated areas, has been contained successfully and rust, formerly widespread and damaging to several varieties, is now of little commercial significance. The mean incidence of ratoon stunting disease in commercial fields in the industry has been more than halved and continues to decline steadily, although it persists at high levels in some areas.

Factors that have contributed to the progress made include effective screening of genotypes undergoing selection for resistance to a number of important diseases, a marked shift from a generally susceptible towards a much more resistant variety disposition in most areas, improved seedcane health in most areas and the development of a greater 'disease control consciousness' among cane growers. The latter two factors have been greatly aided by the successful operation of local pest and disease control committees throughout the industry.

Introduction

A previous review of the status of diseases in the sugar industry (Bailey, 1979) highlighted a generally serious situation, which was having a significant economic impact on productivity. The industry was then largely reliant on varieties susceptible to one or more serious diseases. For example, 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). Both varieties are highly susceptible to sugarcane smut *(Ustilago scitaminea)* and sugarcane mosaic virus (SCMV). The third most widely grown variety in 1978-79, N55/805 (11% of cane crushed in the rainfed areas), is also highly susceptible to smut and was often severely damaged by rust *(Puccinia melanocephala)*.

As a direct consequence of the dependence on susceptible varieties, smut was rapidly increasing in incidence in the warmer, irrigated areas of Pongola and the Eastern Transvaal lowveld and was also becoming more common in some rainfed areas, particularly Umfolosi and Zululand. Surveys also highlighted the increasing problem posed by SCMV in the cooler, high altitude areas of the Natal Midlands and coastal hinterland. Both smut and mosaic were identified as major threats to the industry.

It was clear from the severity of rust on N55/805 that climatic conditions over most of the industry, *viz* periods of relatively cool, wet weather occurring from spring through to autumn, were highly favourable for the development of severe outbreaks of this disease in susceptible varieties.

The bacterial disease leaf scald *(Xanthomonas albilineans)* was first identified in the irrigated areas of the northern region in 1968 and by the late 1970s was found to occur commonly there, although it was rare elsewhere. It was clear from the damage occurring when susceptible varieties were infected that leaf scald constituted a new threat to production and that urgent action was essential to counter this.

In the mid to late 1970s, techniques were developed for the rapid diagnosis of ratoon stunting disease (RSD) on a scale suitable for industrial surveys. Diagnosis is based on the observation of the causal pathogen, the bacterium Clavibacter xyli *subsp xyli*, in extracts of xylem sap. The first results of large scale surveys showed that RSD was common in many areas and was the major cause of crop loss caused by diseases (Bailey, 1979; Bailey and Fox, 1984). An important contributory factor to the widespread occurrence of RSD was its frequent contamination of seedcane stocks (Bailey, 1979).

Red rot *(Glomerella tucumanensis)* was identified in the 1979 review as being a significant problem in the cooler areas of production (Bailey, 1979). However, at that time (before eldana stalk borer became a general pest in the industry) no information was available on varietal reactions to the disease or on the occurrence of red rot in the industry as a whole.

Factors contributing to the serious disease situation that had developed up to the late 1970s, and that in some respects was continuing to deteriorate, were the relatively static variety situation, the poor quality of much of the seedcane being planted and the frequent occurrence of volunteers from old crops in newly planted fields. The significance of the latter two factors is that most sugarcane diseases (the exceptions being the foliar diseases such as rust) are 'systemic' and are readily spread in seedcane and persist in infected volunteer cane.

A multi-faceted strategy was necessary to improve the disease situation in the industry. The most important component of the strategy was to improve the general disease resistance of the new varieties being released to growers. Improvements to the health of seedcane and changes to land preparation practices (to reduce volunteers) were also required.

A key element of the control strategy was to demonstrate to cane growers that diseases were, or could be, causes of substantial reductions in yield, so that preventive measures would be regarded as worthwhile and adopted as routine farm management practices. To achieve this, convincing evidence of yield losses had to be demonstrated and a system of monitoring the occurrence of serious diseases introduced, so that disease hazards could be assessed and the success or otherwise of control efforts observed.

Experimental evidence of the effects of RSD and mosaic (diseases which have subtle or inconspicuous symptoms) on the growth and yield of popular varieties (Bailey and Bechet, 1986; Bailey and Fox, 1987) is regarded as having been useful in demonstrating the importance of these problems to growers.

It was fortunate that the main commercial varieties being grown when leaf scald was first identified in South Africa were resistant. All varieties released since then have been highly resistant and, although the pathogen remains common in the northern region, leaf scald has had no impact on production (Bechet *et al*, 1992). A continuance of current variety testing and release policies should maintain this satisfactory situation.

Seedcane

The health of seedcane being grown in the industry is probably better now than at any stage in the industry's history. This progress was only possible with the establishment of local pest and disease control committees (LP&DCCs) in all mill supply areas in 1982 (Paxton, 1983, Tucker and Rowland, 1987). The committees have paid particular attention to the seedcane needs of growers.

Today, effective seedcane production schemes operate throughout the industry. The details differ from area to area but all schemes incorporate regular hot water treatment (HWT) to control RSD, and all that are based on conventional seedcane involve regular inspections, strict standards of nursery management and certification of acceptable freedom from serious diseases before seedcane can be used or sold for planting.

In some areas, increasing use is being made of transplants generated from single-budded setts to propagate seedcane. This system offers advantages in varietal purity, freedom from diseases and rapid propagation of new varieties, but for success it requires a high level of management in transplant nurseries.

Improvements made in seedcane health have been a major factor in reducing the incidence of RSD in the industry, and have also been important in minimising the spread of smut and mosaic.

Monitoring disease incidence

LP&DCC survey teams routinely monitor the occurrence of the important diseases smut and mosaic on a large scale. The surveys identify problem fields with high disease levels, which constitute reservoirs for further spread and which require control measures by the grower, such as roguing or ploughing out. Information from the surveys is also used to monitor disease trends and guide variety release decisions for different areas.

The monitoring of RSD levels in all areas is a function of the RSD diagnostic service of SASEX. Information on the frequency of RSD in commercial cane fields and in intended seedcane sources highlights the importance of this disease, and provides a continual incentive to maintain control efforts in all areas. It also enables the grower to identify infested fields and take appropriate management action.

Surveys of new, uncommon or 'non-routine' diseases are a responsibility of the specialist pathology staff of SASEX.

Control of volunteers

The importance of volunteers in enabling systemic diseases to persist in cane fields is now well recognised in the industry. Research on crop destruction techniques, such as shallow ploughing, minimum tillage and combination tillage (Butler, 1992; Dicks *et al.*, 1981), and recommendations on the specific circumstances under which they are best used has greatly improved this aspect of crop management, with associated benefits in disease control.

Specific disease control measures

In addition to the general disease control measures (varietal resistance, and improvements in seedcane health and methods of crop destruction), a number of specific measures for individual diseases have been applied successfully. Among these, roguing, if applied correctly, was shown to be a successful, cost-effective method of controlling smut in all but the most highly susceptible varieties (Anon, 1990a; de Lange and McGugan, 1989; Pearse 1989).

Research also led to an understanding of the factors affecting vector-borne spread of SCMV. These findings were applied in time-of-planting recommendations to avoid infection in areas where SCMV was particularly likely to occur (Bailey and Fox, 1980; Harborne, 1988).

Both the above measures were incorporated in LP&DCC regulations for certain areas. Practical measures to minimise the spread of RSD have also been developed, based on research findings on the transmission of *C. xyli* subsp *xyli* (Bailey and Tough, 1992a and b).

Trends in the Incidence of Major Diseases

Smut

Since the replacement of susceptible varieties in the previously seriously infested northern irrigated areas, and the more recent change towards resistant varieties in the rainfed

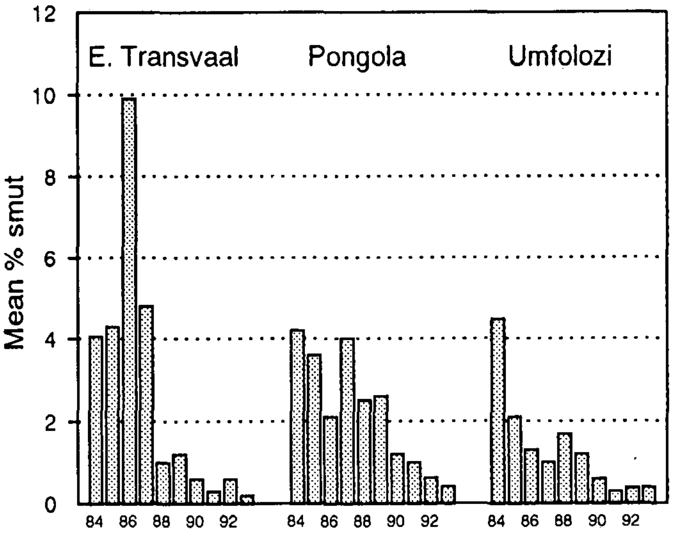

FIGURE 3 Smut survey results from Eastern Transvaal, Pongola and Umfolozi, 1984 to 1993 (mean % stools with smut).

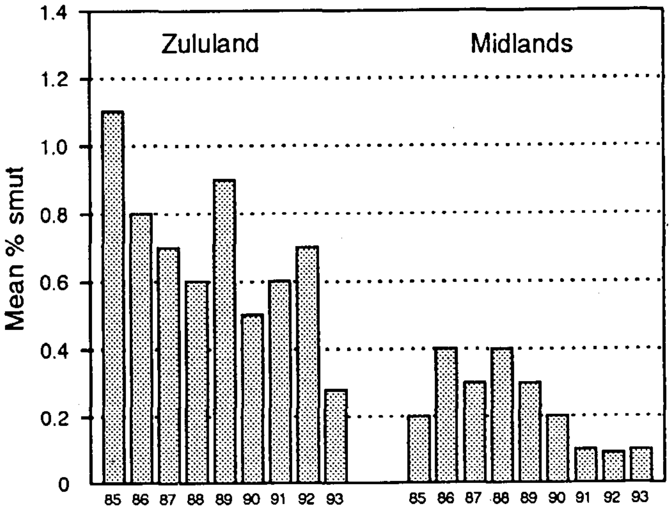

FIGURE 4 Smut survey results from Zululand and Midlands, 1985 to 1993 (mean % stools with symptoms).

This paper reviews the current disease situation and the progress made in reducing the incidence of formerly more common, serious diseases. The improvements made to the underlying factors that contribute to the occurrence of diseases in sugarcane are also described.

Factors Affecting Disease Incidence

Varieties

From 1975, techniques for the screening of new genotypes undergoing selection for resistance to most important diseases have been introduced and refined. This programme is arguably the most important pathology activity at SASEX. Active screening (involving special trials and using inoculation techniques and/or enhanced levels of pathogens) is practised for leaf scald, smut and mosaic (Bailey and Bechet, 1982; Bechet *et al*, 1992). Active screening for resistance to red rot commenced in 1989. Resistance to rust and other common and highly infectious diseases, including gumming and a number of leaf spots, is achieved by rigorous selection in routine selection trials.

Consideration has also been given to improving the resistance of progeny to important diseases, particularly leaf scald, mosaic and smut, when parent varieties for crossing are chosen.

Except for RSD, for which no rapid practical test to determine varietal reactions is yet available, resistance to common and serious pathogens has been a prerequisite for new varieties to be released for more than 15 years. This policy 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. Thus N19, which is susceptible to mosaic, was released for the warmer areas, where mosaic is considered unlikely to become a problem.

Further improvements to disease screening procedures are likely in the near future. The testing of larger numbers of new genotypes at earlier stages of selection for resistance to smut and mosaic by conventional means is currently under consideration. Looking further ahead, the testing of large numbers of genotypes by indirect means is under investigation. Near-infrared analysis (NIR) shows promise for identifying genotypes with different reactions to mosaic and may have application to other diseases.

Perhaps the greatest progress would be made if tests could be developed to indicate varietal reactions to RSD, and if sufficient variation in reactions to this disease to permit useful selection was found among the local gene pool. Serologically based techniques show some promise for this line of research.

The general resistance of the varieties released to the industry since the late 1970s, and which represent an ever increasing proportion of the industrial crop, has improved markedly. The resistance of the most widely grown and new varieties to smut is shown in Figure 1. In contrast with the situation in 1979, smut-susceptible varieties such as NCo376, NCo310 and NCo293 now constitute a minor proportion of the crop and production in the northern areas, where smut was formerly regarded as a major threat, is now entirely based on resistant varieties (Table 1). Currently these are mainly N14, N17, N19 and CP66/1043, and N22, N23 and N24 are being propagated further.

The resistance of the newer varieties to mosaic compared with NCo376 and NCo293 has also improved markedly (Figure 2). The crop in the areas where mosaic was formerly most common is now composed almost entirely of resistant varieties, predominantly N12 and N16 (Table 1). The new variety 80L432, currently being propagated with a view to possible release in the rainfed areas in spring 1994, is also resistant to mosaic.

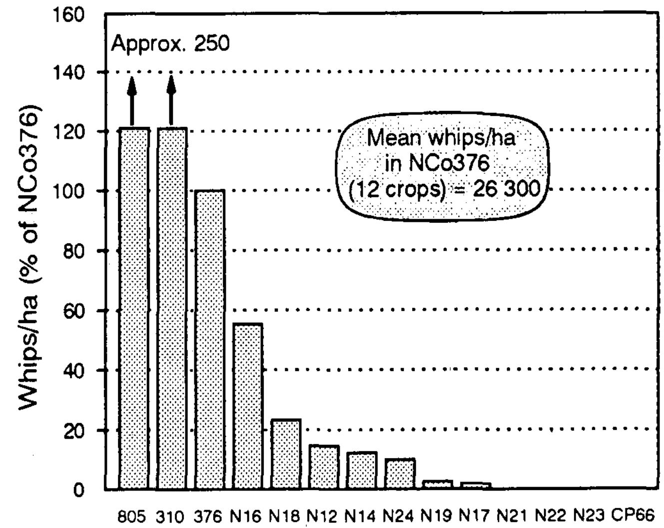

FIGURE 1 Reactions of sugarcane varieties grown in South Africa to smut (whips/ha relative to NCo376).

Table 1

Percentage of smut and mosaic susceptible varieties contributing to the cane crop in the industry and in different areas, 1978-79 and 1993-94

Area	Smut		Mosaic	
	1978–79	1993–94	1978–79	1993–94
Industry	97	38	81	37
Irrigated northern areas	99	0	94	19
Southern rainfed areas (exc Midlands)	92	45	79	42
Midlands	92	27	84	13

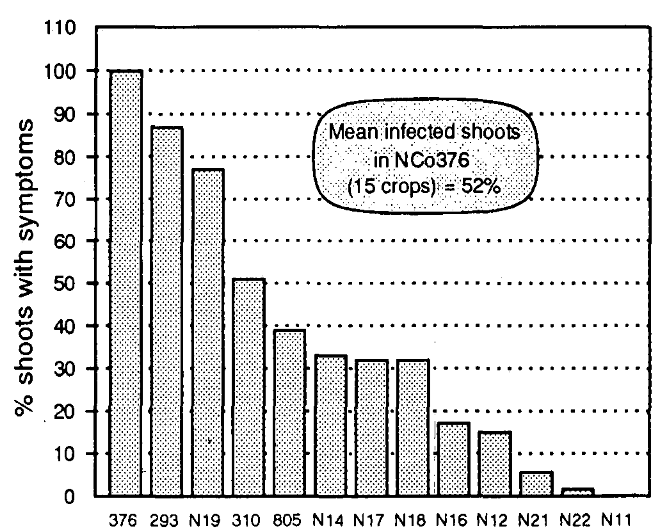

FIGURE 2 Reactions of sugarcane varieties grown in South Africa to mosaic (% shoots with symptoms relative to NCo376).

areas that is still in progress (Table 1), smut is no longer regarded as a serious threat to the industry. Survey data from the northern region demonstrate a marked decline in smut incidence (Figure 3). Similar reductions in the occurrence of smut have been recorded elsewhere (Figure 4).

Climatic and environmental conditions over much of the industry are still favourable for the development of smut in susceptible varieties but, provided the policy of releasing only resistant varieties is maintained, the economic impact of this disease should remain small.

Mosaic

The threat that mosaic formerly presented to cane production in the cooler areas of production is now greatly reduced. For example, mean levels of mosaic in commercial cane fields in the South Coast hinterland and in the Midlands areas have declined markedly (Figure 5). Success in controlling mosaic has been largely due to changes in varieties, but the adoption of a number of measures in an integrated approach also proved beneficial (Neen and Armitage, 1988). Although variety N12 is much more resistant than NCo376 (Figure 2), an even greater degree of resistance than that of N12 is desirable in the coolest areas, where mosaic is most likely to occur.

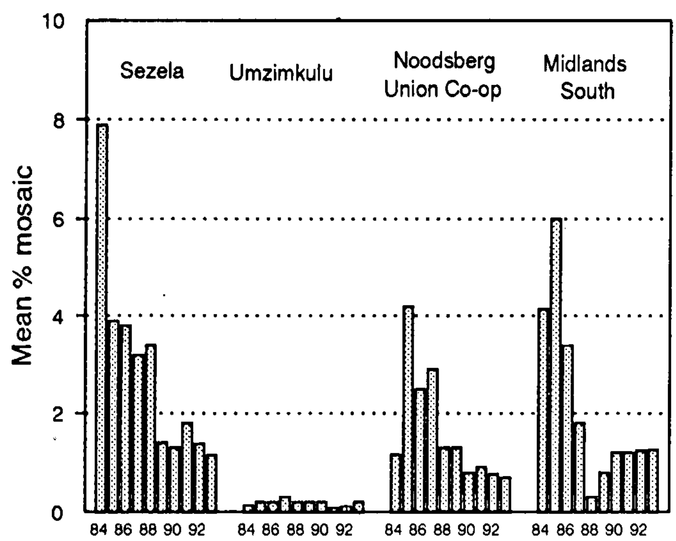

FIGURE 5 Mosaic survey results from South Coast and Midlands areas, 1984 to 1993 (mean % stools with symptoms).

The Nkwaleni valley of central Zululand remains a 'mosaic hot spot', mainly because of the lack of mosaic resistant varieties suited to the area. It is unfortunate that the high susceptibility of N19 appears to preclude this otherwise valuable variety from the area. Nevertheless, the rate at which new varieties suited to production under irrigation are emerging from the selection programme should ensure that areas such as Nkwaleni and the new irrigated area at Heatonville are well served with mosaic resistant varieties in future.

Ratoon stunting disease

The mean incidence of RSD in commercial cane in the industry as a whole has declined steadily since large scale surveys started (Bailey and Fox, 1984; Bailey and Tough, 1991). In 1993 a mean of 13% of commercial fields were found to be infected. This represents an improvement of more than 50% since the late 1970s (Figure 6) and is the lowest mean incidence yet recorded. Much of this improvement can be ascribed to greatly improved seedcane quality.

The mean incidence of RSD in intended sources of seedcane had declined to 5% sources infected in 1993, again the lowest yet recorded (Figure 6). Most intended sources of seedcane throughout the industry are checked by the RSD diagnostic service of SASEX and those found to be infected are discarded. As a consequence, seedcane planted in most areas is now effectively RSD-free.

Despite the general improvement in the RSD situation, high levels persist in certain areas, particularly in the warmer, more northerly areas of production such as Pongola (Figure 7).

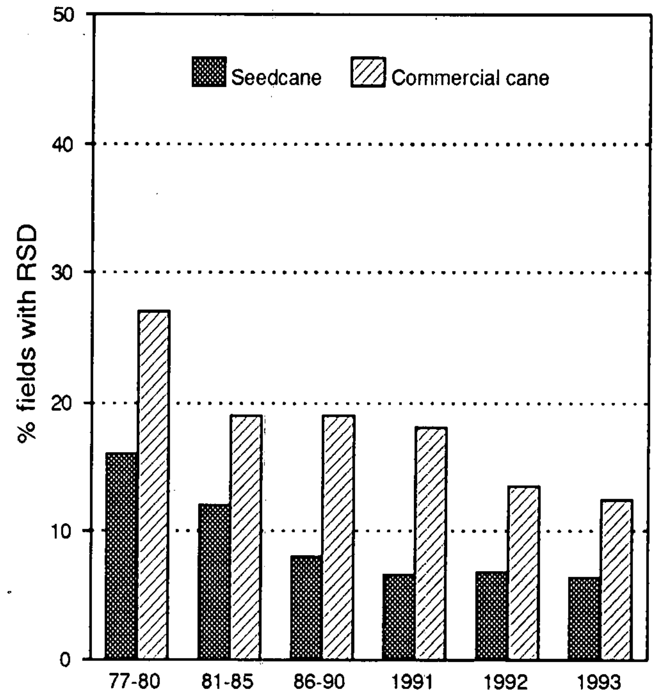

FIGURE 6 The RSD situation in the industry, 1977-93.

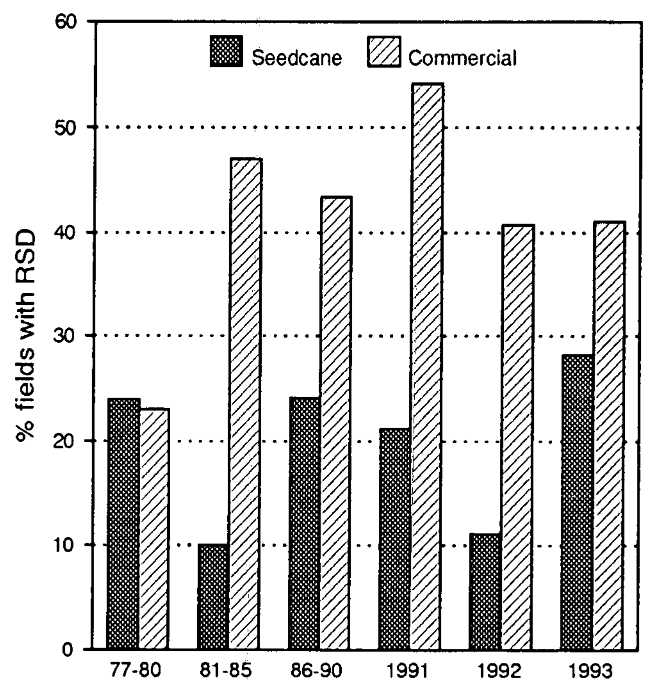

FIGURE 7 The RSD situation in the Pongola area, 1977-93.

Recent research has demonstrated that *C. xyli* subsp *xyli* can survive in soil after RSD-infected crops are destroyed and may infect newly planted crops (Bailey and Tough, 1992a). This highly significant finding may be a major contributory factor to the persistence of RSD in some areas. Supporting evidence of this comes from Swaziland, where an industrial survey in 1992 showed that 28% of commercial fields were infested, despite the operation of an effective seedcane scheme since the late 1970s (Swaziland Sugar Association Extension Services, unpublished data).

RSD diagnosis on a large scale, together with the results of field trials on the effect of RSD on yield, permits an estimate of the economic impact of the disease. In 1993, the loss throughout the industry is estimated to have amounted to approximately 2% of production. Losses in different areas ranged from negligible to much greater than the industrial mean.

Red rot

Industrial surveys conducted from 1988 to 1992 confirmed earlier views that red rot was a cause of substantial crop loss. It was shown in the rainfed areas that red rot was present in a mean of 0,45% internodes per stalk, causing an estimated crop loss of approximately 2%. Much of the infection was found to be associated with damage from stalk borers (Anon, 1990b; Trenor and Bailey, 1989). The frequency of red rot was also found to be associated with cane age and variety (Anon, 1990b).

Any factor that reduces the incidence of borer damage will reduce the incidence of red rot. Otherwise, control of this disease can be effected only by varietal resistance. Results from both surveys and controlled experiments showed that N13 was by far the most susceptible and N12 and N14 the most resistant varieties. A routine screening test based on inoculation was introduced at a late stage of selection in 1992, so that highly susceptible genotypes like N13 could be identified and discarded.

Conclusions

Good progress has been made in reducing the economic effects of diseases in the South African sugar industry. Adherence to current policies regarding disease resistance screening and variety release is necessary. Further progress in the reduction of the economic impact of RSD and advances in screening for resistance to diseases can be expected. New biotechnological techniques are likely to be increasingly applied for tasks such as the screening of new genotypes for resistance and the diagnosis of pathogens.

The progress made in disease control in the industry has been due to the co-ordinated efforts of many parties, including SASEX research workers and extension staff, LP&DC committees and their technical staff, and opinion leaders among growers in all areas.

Acknowledgements

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