FLUCTUATIONS IN THE LEVELS OF SMUT (*USTILAGO SCITAMINEA*) IN RESPONSE TO CHANGES IN DISEASE MANAGEMENT STRATEGIES IN THE ZIMBABWE SUGAR INDUSTRY

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Abstract

Sugarcane smut (*Ustilago scitaminea* H&P Sydow) in Zimbabwe was first recorded in 1946, and remains the most economically important fungal disease of the crop. The disease is estimated to reduce sugarcane yields by 15% in susceptible varieties such as NCo376. Various control measures, including the replacement of susceptible varieties with more resistant varieties, voluntary and regulated seedcane certification schemes, systematic roguing of diseased plants and treatment of seedcane setts with fungicides before planting, have been introduced in an integrated manner to manage the disease, with varying levels of success.

This paper describes survey methods used in the Zimbabwe sugar industry to determine the incidence of smut in commercial fields across the industry. It explains the increases and decreases in smut incidence from 1972 to 2007 in response to management interventions. The negative impact of land reforms in Zimbabwe on the prevalence of smut is also highlighted. The paper argues that the future of smut control lies in widespread adoption of resistant varieties by growers.

Keywords: Zimbabwe, sugarcane, smut, *Ustilago scitaminea*, disease control, disease resistance

Introduction

Sugarcane is grown under irrigation in the semi-arid southeast lowveld of Zimbabwe (20ºS, 30ºE; 400-500 masl), where climatic conditions allow the crop to be grown on a 12-month cycle. There are almost 45 000 hectares of sugarcane plantations in the lowveld. The Zimbabwe sugar industry (ZSI) comprises Triangle Sugar Corporation (Triangle Ltd, Hippo Valley Estates Ltd and Mkwasine Estate), Chisumbanje ARDA Estate, about 840 small to medium scale out-growers grouped under the Commercial Sugarcane Farmers' Association of Zimbabwe (CSFAZ) and the Zimbabwe Cane Farmers' Association (ZCFA). Approximately 9 000 ha are privately owned and managed under CSFAZ and ZCFA.

Sugarcane smut (*Ustilago scitaminea* H&P Sydow) is an important disease in most sugarcane growing countries of the world. The disease was first reported in Zimbabwe in 1946 (James, 1968). Smut established quickly and remains the most widespread and economically important fungal disease of the crop (James, 1968; Anon, 1993). The high temperatures in the sugarcane growing areas of Zimbabwe are conducive to the development of smut and the disease is endemic. Smut is estimated to reduce sugarcane yields by 15% in susceptible varieties such as NCo376 (James, 1973, 1974). The disease was contained by intensive application of field control measures, including the planting of disease-free seedcane, roguing of smutted plants and ploughing out of severely infected crops (Anon, 1993). The prevalence of smut was one of the main reasons for the establishment of the Zimbabwe Sugar Association Experiment Station (ZSAES) and the variety breeding and selection programme.

Regular, systematic surveys to monitor the incidence of smut in the ZSI started in 1972 and have continued on an annual basis. A specially trained team of disease scouts under ZSAES conducts surveys for the disease in commercial and seedcane fields. The surveys, traditionally done from September to May, are designed to cover all sugarcane growing areas. Smut levels are monitored and areas where farmers are failing to manage the disease satisfactorily are highlighted. This information allows the industry to formulate appropriate management strategies to reduce the risk of smut epidemics. The ZSI initially set 1% mean smut infection as the highest level allowed in fields (Anon, 1993). This target was reduced to 0.3% following the release for commercial production of variety N14, which was at that time more resistant to smut than the popular and widely grown variety NCo376 (Anon, 1998).

This paper reports on the trends in smut infection in the ZSI from 1972 to 2007 and relates disease levels to control methods employed. It also highlights the negative impact of land reforms in Zimbabwe on the prevalence of smut.

Materials and Methods

Smut surveys in commercial fields

Selection of fields: Ratoon fields, with cane of about five months old, were randomly selected from crop returns submitted by estates and private growers. These returns gave details of the grower, field number, variety, area, and planting and harvesting dates. Although crops in the second to fourth ratoon were targeted for inspection, as they had been observed to have a higher smut incidence, other ratoons were also inspected in order to have a better representation of the industry. The grower's smut control programme was not taken into account when selecting fields for inspection. The target was to inspect 20-25% of the total area harvested per year and, for logistical reasons, a sample area of 5.25% of each field was selected to represent the entire field.

Survey procedure: Scouts identified, counted and recorded all incipient and open smut whips in randomly selected sample areas, which comprised 10 x 35 m rows with 1.5 m row spacing (= 525 m^2). The length of row to be inspected was measured using a 35 m rope. Each sample area represented one hectare, and a minimum of three samples were taken from every field.

Calculation of percentage smut infection: The smut counts from the 525 m^2 sample areas were collated and used to calculate % smut infection for the field using the following formula:

$$\% \text{ smut infection} = \frac{W}{n} \times \frac{10\,000}{525} \times \frac{100}{MSP}$$

where W = total number of whips counted in all sample areas
n = number of samples
525 = sampling area in m^2
MSP = mean stalk population per ha for the variety (the average number of millable stalks from ZSAES trials in the breeding programme).

Mean % smut infections weighted for area were calculated for each variety, estate or grower, month of inspection and ratoon for each season. Disease incidence was then related to the practices introduced by the ZSAES in response to increasing smut pressures.

Results and Discussion

From 1972 to 1978, the annual mean % smut infection peaked at 1.4% in 1974 because the two most widely grown varieties, NCo310 and NCo376, were highly susceptible to the disease (Figure 1). In 1972, NCo310 was withdrawn as a recommended variety and was eventually banned from production in 1979 (Anon, 1979). By 1978, NCo376 accounted for 98% of the area under sugarcane production. The industry relied on voluntary seedcane certification, roguing of smut from fields and the ploughing out of severely infected fields to manage smut. Planting of seedcane that had been inspected and certified free of diseases, in particular smut, by the Zimbabwe (then Rhodesia) Sugar Association Experiment Station was done on a voluntary basis, but few farmers adopted this practice. These interventions, together with the withdrawal of NCo310 from production, were partially successful in reducing smut levels from 1.4 to 0.7% (Figure 1).

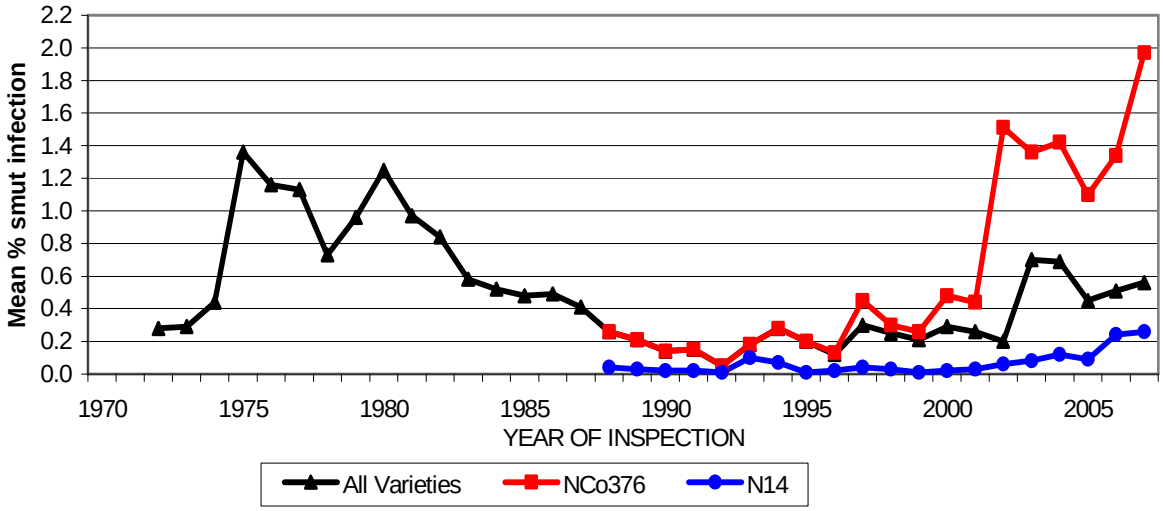

Figure 1. Mean annual % smut infection recorded in the Zimbabwe sugar industry from 1972 to 2007. 'All varieties' consisted of NCo376 and NCo310 up to 1979; mainly NCo376 up to 1985; NCo376 and N14 up to 1995; NCo376, N14, ZN1L, ZN2E and CP72-1312 up to 1999; and the 14 varieties released after 2000.

NCo376 remained the predominant variety between 1979 and 1985, accounting for nearly 97% of the area under cane. The incidence of smut again increased, reaching a level of 1.24% in 1980 (Figure 1). The industry responded by recommending the use of a fungicide, particularly triadimefon, as a pre-plant seedcane dip (Anon, 1985). A compulsory seedcane certification scheme was introduced in 1981, and this regulation compelled growers to use certified, disease-free seedcane for all new plantings. These new interventions, together with the other previously recommended cultural practices, reduced smut levels to 0.5% by 1985 (Figure 1).

From 1986 to 1991, a further reduction in the levels of smut to about 0.18% was observed (Figure 1). This was mainly due to the integrated management programme introduced between 1979 and 1985, but was also influenced by the release in 1985 of the moderately resistant variety N14 for commercial production (Anon, 1995). The area under NCo376 declined to below 90% as N14 became established in the industry. The industry adopted Sugarcane Smut Control Regulations in 1991 (Anon, 1995), the aim of which were to monitor

and control the levels of smut in sugarcane. The regulations outlined the duties required of growers to contain smut at levels below those set by the ZSAES, and enforced the growing of only those varieties approved and recommended by the Experiment Station. The regulations also empowered the ZSAES to serve and enforce ploughout orders for fields with smut levels in excess of 4% infection. With these regulations in place, smut was largely contained at levels below the industry-wide target of a mean of 0.3% smut infection.

The sugar industry in Zimbabwe was almost decimated by drought in 1991/92. Consequently, surveys for smut were scaled down, resulting in recorded disease levels dipping below 0.1% (Figure 1). Smut levels increased to 0.24% by 1994 (Figure 1) as a result of the re-establishment of sugarcane fields with, in many cases, smut-infected seedcane because of severe shortages of clean seedcane (Anon, 1995). Two smut resistant varieties, ZN1L and ZN2E, and one moderately resistant variety, CP72-1312, were released for commercial production in 1995 (Zhou, 1996).

The three varieties released in 1995, particularly CP72-1312, were becoming established in the industry (Figure 2) and, together with N14, which by then accounted for about 30% of cane production, kept smut levels below 0.3% (Figure 1). A slight upsurge in smut levels in variety NCo376 during this period was as a result of renewed interest in hot water treatment of seedcane to eradicate ratoon stunt. This practice is known to increase the susceptibility of NCo376 to smut (Bailey, 1977). A further five smut resistant varieties were released in 1999, *viz*. ZN3L, ZN4, ZN5, ZN6 and CP72-2086 (Anon, 2000) and, as the area under these varieties increased, the overall smut incidence was maintained below 0.3% (Anon, 2003). Breeding lines at the ZSAES are becoming progressively more smut-resistant (Zhou, 1998), hence new releases have greater resistance to the disease.

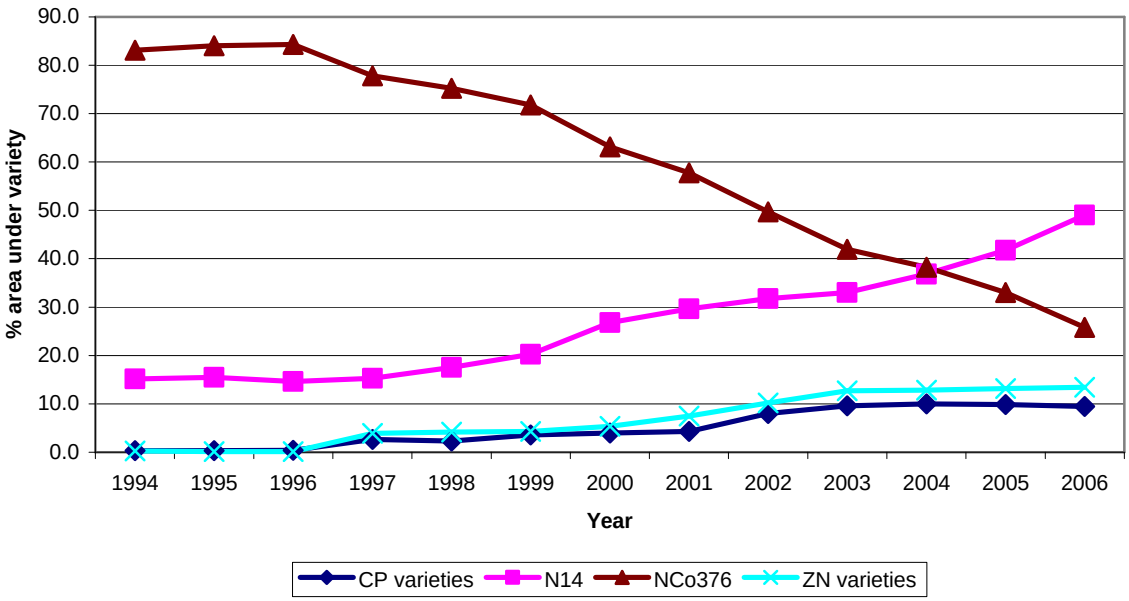

Figure 2. Percentage area in the Zimbabwe sugar industry grown to a single variety or group of varieties from 1994 to 2006. CP varieties were CP72-1312 and CP72-2086 bred at Canal Point, USA; ZN varieties were nine releases crossed in Natal, RSA, and selected in Zimbabwe.

In 2001, the Government of Zimbabwe introduced the Land Reform Programme which saw tracts of sugarcane land owned by white commercial farmers being distributed to black people from 2002 onwards. The majority of the new farmers had no experience in farming, nor did

they have the resources to grow sugarcane. On some farms, sugarcane diseases developed without any attempts at control, and this contributed to the upsurge of the mean smut level to 0.69% in 2004 (Figure 1). The incidence of smut in NCo376 increased rapidly to 1.97% in 2007 (Figure 1).

From 2002, the incidence of smut in NCo376 was substantially higher on private farms than on estates (Figure 3). Prior to this, private growers had managed smut as effectively as had the estates (Figure 3). In addition, from 2002 to 2007, fields with crops exceeding 4% smut infection on private farms increased from less than 10 to over 30 per year (data not shown).

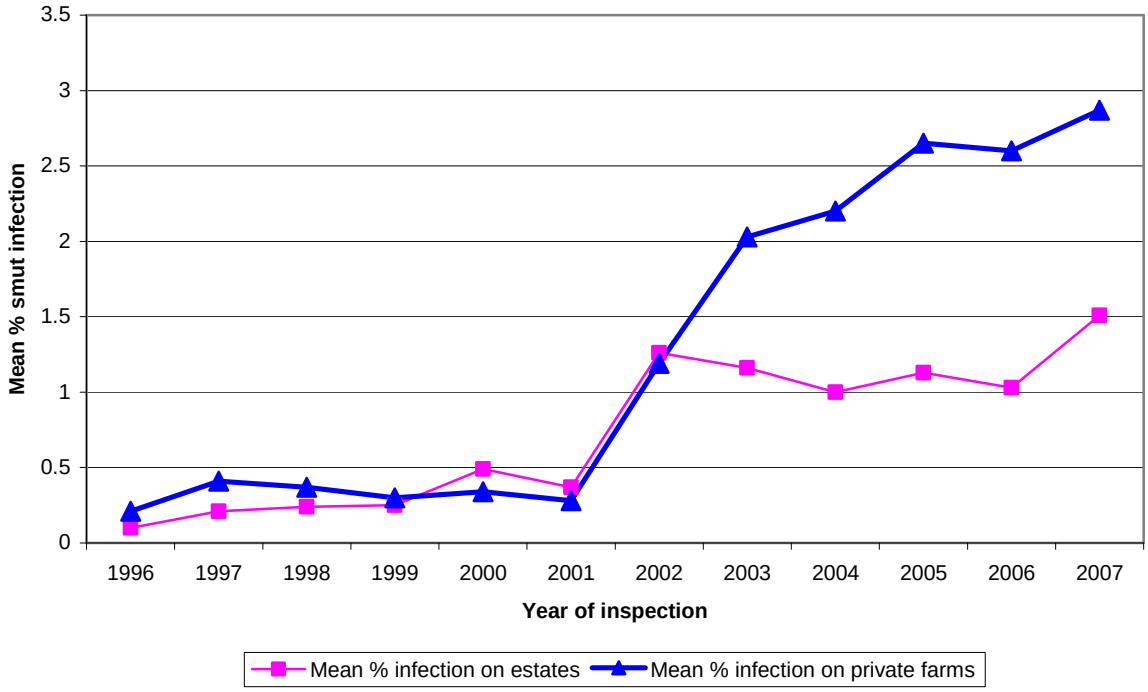

Figure 3. Weighted mean % smut infection in variety NCo376, showing the increase in the incidence of smut on privately owned farms compared to the incidence on estates following the Land Reform Programme introduced in 2001 in Zimbabwe.

The general increase in smut levels was exacerbated by a shortage of labour to rogue out diseased stools from the fields (Anon, 2007). The economic crisis experienced in Zimbabwe during this period had resulted in the migration of general and skilled labour to South Africa and other countries.

Variety dispositions and smut incidences

The variety disposition from 1994 to 2006 is shown in Figure 2. The area under N14 increased to 49% of total area by 2006, while the area under NCo376 declined to 26% (Figure 2). The remainder of the area was grown to the two CP varieties (10%), nine ZN varieties (13%) and mixed varieties (2%). The incidence of smut in the ZN and CP varieties generally remained below 0.1% (Figure 4), while that for N14 exceeded 0.2% during 2006 and 2007 (Figure 4), raising fears that this variety may succumb to smut as happened in Malawi (Isyagi and Whitbread, 2002).

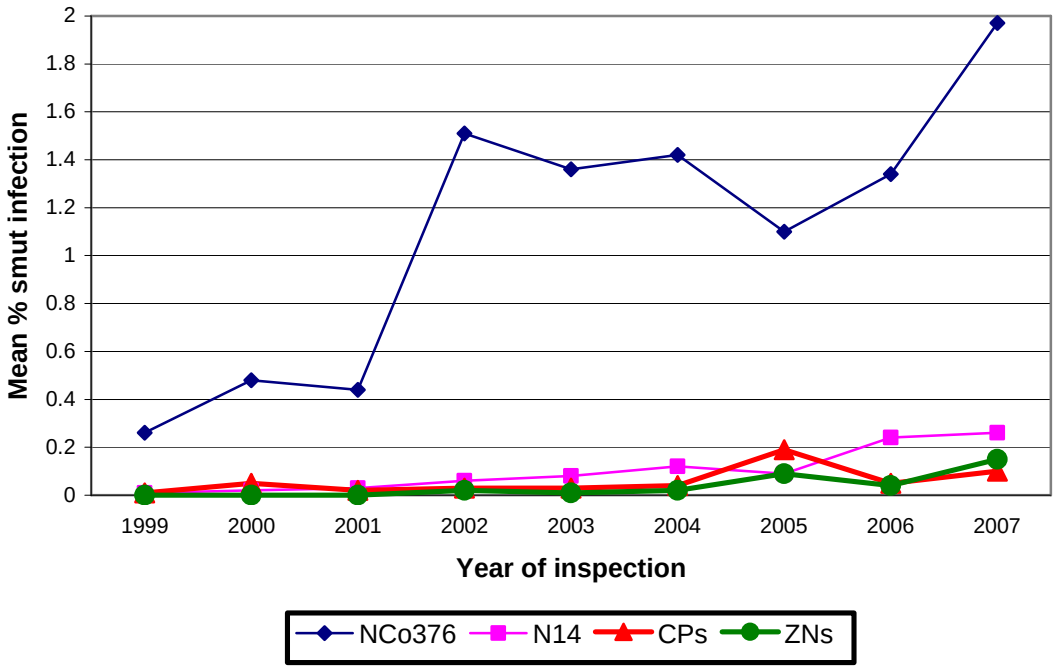

Figure 4. Mean % smut infection in the commercial varieties grown in Zimbabwe from 1999 to 2007.

Conclusion

Data from regular smut surveys has served the ZSI well from the time of introduction. Critical and timely decisions were made in an effort to manage smut. In most seasons, the disease was kept below economic levels even though the predominant varieties, NCo376 and NCo310, were highly susceptible. Integrated strategies employed from time to time were effective in managing smut, but were not long term. Roguing, one of the key elements in the control strategy, was labour-intensive as it had to be done up to seven times in a season in heavily infected fields.

Many of the new varieties introduced into the industry after NCo376 and NCo310 were not readily adopted. N14 was the exception and has now become the predominant variety in Zimbabwe, and its popularity appears to be increasing. This situation is not ideal from a disease management point of view, and already smut levels are increasing in this variety. Eleven varieties with excellent field resistance to smut have been released for commercial production since 1995, but none of these have exceeded 10% of production area for various reasons. The breeding and selection programme should continue to search for varieties that are not only resistant to smut and other diseases, but have agronomic characteristics that appeal to growers. Varietal resistance is the only long-term solution in smut control, particularly where labour availability is limited and there is the need to remain a low cost sugar producer.

The Land Reform Programme introduced by the Government of Zimbabwe has resulted in increased levels of smut. The majority of beneficiaries do not have the technical knowledge to grow sugarcane or to manage diseases on the farms. Extension programmes must be pursued to address this deficiency.

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