

Occurrence and Spread of Sugarcane Smut Caused by *Ustilago scitaminea* in Morocco

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ABSTRACT

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Smut caused by *Ustilago scitaminea* was introduced into Morocco, and all major sugarcane cultivars grown in the Gharb and Loukkous regions were infected. Only the Moulouya region of Morocco has remained free from infection. Pathogenicity tests indicated that smut is most severe in ratoon crops. The disease is now widespread and the area infected increased from 12% in 1993 to 35% in 1995 in the Gharb region. In the Loukkous region, the hectareage infected increased from 14 to 69% during the same period. The incidence of smut initially was very low, with less than 100 whips per ha in 1993, but increased to more than 5,000 whips per ha in 1995. Sanitation measures to reduce inoculum potential have been implemented and resistant cultivars are being developed and will be released as possible replacements for the susceptible cultivars L72.85, CP65.357, and L62.96.

Sugarcane (*Saccharum officinarum* L.) forms a basic food for Moroccans and is an essential ingredient for making the national drink (menthe tea). The annual consumption is among the highest in the world and stands at about 29.5 kg per capita. The total sugar production amounted to 500,000 metric tons in 1995 with sugar cane accounting for 29% of this amount (5). The production of sugar from both sugarcane and sugar beet covers only two-thirds of the national consumption.

Sugarcane is a perennial plant propagated through cuttings, pieces of stem with axillary buds, and grown in monoculture. It is typically harvested annually for 5 years. It covers about 17,000 ha along the coastal regions of north Morocco, namely the Gharb (11,500 ha), the Loukkous (5,000 ha), and the Moulouya (500 ha). During the 1970s and 1980s, sugarcane in Morocco was free from major diseases affecting sugarcane elsewhere. A list of parasitic and nonparasitic diseases occurring in Morocco was compiled by Autrey et al. (8). Recently, sugarcane smut caused by *Ustilago scitaminea* Syd. & P. Syd. was introduced into Morocco (1) and threatens the well-being of the sugar industry. Subsequent surveys show that the disease is widespread in the Gharb and Loukkous and all major cultivars are infected with smut.

Sugarcane smut is a disease of major economic importance wherever the crop is

grown, causing serious losses particularly in susceptible cultivars (15,17). Sugar production is reduced through losses in cane tonnage from 12 to 73%, as has been shown in studies in various producing areas of the world (9,18,20), and through reduction of cane juice quality (21). Greater yield losses are incurred in ratoons than in planted cane crops (15).

The typical symptom of smut is a sorus. A sorus is made up of a fairly hard core of parenchyma and fibro-vascular tissues surrounded by millions of spores enclosed, in the earlier stages, within a thin, silvery, membranous sheath. A sorus develops from the top of an infected stalk and the whole structure is called a whip. The whips are usually straight when short and become irregularly curved when 1 to 1.5 m long (6). Incipient whips are infected shoots, erect with elongated internodes, but more spindly than healthy shoots. The numbers and proportions of whips in planted cane crops and successive ratoons have been used to classify cultivar response to smut (24), and to evaluate incidence of smut in Louisiana (16). In Morocco, infected fields of cv. L72.85 with more than 5,000 whips per ha have been recommended for plowing following their crop harvest (7).

The present paper describes this new disease of sugarcane in Morocco and the development of smut epidemics in the Gharb and Loukkous regions and summarizes the results of surveys conducted since the introduction of smut.

MATERIALS AND METHODS

Smut was identified primarily by visual symptoms on sugarcane plants and measurement of teliospores. Teliospores from infected stools of L72.85 showing typical

symptoms were mounted in water and a drop of Tween 20 on a glass slide, and measured with an ocular micrometer at a magnification of $\times 400$. Five hundred teliospores were measured. Also, a sample of teliospores was sent to E. Mordue at the International Mycological Institute (IMI), Surrey, England, for identification.

Inoculum for pathogenicity tests was prepared from five freshly collected whips. The spores of five whips were suspended in 1 liter of water with a few drops of Tween 20 to prevent clumping. The suspension was adjusted to 6×10^6 spores per ml. Twenty-five cuttings, each with three buds, were selected from apparently healthy plants. The cuttings were treated with hot water at 52°C for 20 min and then at 50°C for 45 min 24 h later. The hot water treatment is used as a phytosanitary measure to obtain disease-free materials from stock that may have systemic smut infection (10,15). The cuttings were then immersed for 30 min in the spore suspension and kept covered with moistened tissue overnight to enhance infection (11,13, 22). Inoculated cuttings were planted 24 h later in large pots (37 cm diameter and 48 cm height), containing a 2:1 (vol/vol) mixture of Biosol (SUCRAL, Larache, Morocco) and sand in a greenhouse maintained at 30 to 35°C. Pots were watered as needed and periodically examined for symptoms of sugarcane smut. Plants resulting from inoculated cuttings were grown as planted cane crops (6 months) and as two successive ratoons (6 months each).

Incidence of smut infection in commercial fields was determined by 11 teams of two to three people each. The surveys were conducted in the Gharb region each summer, from June to August in 1993, 1994, and 1995, when the cane was 3 to 6 months old, by inspecting systematically each sugarcane field. However, in the Loukkous region, surveys were conducted at random and the area inspected covered about 1,000 ha, where sugarcane is grown in heavy soil and sprinkler irrigated.

Cultivars were identified from directories of growers maintained by sugar factories. Each team was assigned a particular factory area. Within a field, counts of incipient and formed whips were made in a 750 m² area (a 10-m section in each of 50 rows). The number of areas sampled increased with the field size and was as follows: 3 \times 750 m² for fields less than 5 ha;

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6 × 750 m² for fields between 5 and 10 ha; and finally 10 × 750 m² for fields over 10 ha.

Disease progress was monitored in a 0.5-ha field grown with L72.85 naturally infected with smut. Eighty stools were chosen and numbered from 1 to 80. Fortnightly, the stools were visually checked for the presence of incipient and formed whips. Each identified whip was cut at 5 cm below ground level, where it joined the crown, to prevent compensating tillering. The number of whips recovered at each sampling date was recorded.

RESULTS AND DISCUSSION

Smut was identified primarily by visual symptoms and signs, i.e., whiplike sori emerging from the apex of L72.85, at the Technical Center of Sugar Crops (CTCS) and subsequently in other fields grown from cultivars L72.85, CP65.357, and

L62.96. The sorus consisted of a hard core of fibrous tissues surrounded by masses of teliospores encased in a membranous sheath. The pathogen was identified as *Ustilago scitaminea* on the basis of host symptoms including the whip and the development of stunted and grassy stools on L72.85, and brown and punctuate teliospores 5.1 to 7.8 µm in diameter. The identification was confirmed by E. J. Mordue (IMI, Surrey, England).

The results of pathogenicity tests showed that smut infection was more severe in ratoon crops than in the planted cane crop. The percentage of infected stools increased from 23% in the planted cane crop to 85 and 98% in the first and second ratoon crops, respectively. During the same crop cycle, the mean number of whips per stool increased from 1.3 in the planted cane crop to 2.4 and 2.8 in the following ratoon crops.

Disease was monitored regularly during the active growing season of sugarcane in the Gharb. The first whip was observed early in May, 10 weeks after emergence of cane shoots (Fig. 1). Disease incidence increased slowly during May and June, followed by a rapid increase in July and finally a decline in the rate of appearance of new whips in August. The rate of disease increase was not constant and showed three major fluctuations. The increase in the rate of appearance of new whips in July corresponded to a period of rapid growth of sugarcane and was probably caused by high temperatures, which seem to favor symptom expression. This progress curve of sugarcane smut on L72.85 was similar to that described by Amorim et al. (4) as a double sigmoid and suggests a variable infection rate.

Sugarcane smut was found in the Gharb and Loukkous. The original infection site was located at the CTCS, which is the main supplier of seed cane to farmers of both infected areas. The Moulouya area remained free from smut infection, as this area is remote from the CTCS and has not been supplied with cuttings from the CTCS since 1991. Smut in the Gharb and Loukkous evidently is spread to other fields primarily through cuttings. Forty-two percent of fields planted from material that originated from the CTCS were found infected in planted cane crops. In the first ratoon crop, the incidence of smut increased to 69%. The increase was probably due to wind-dispersed spores, as L72.85 and CP65.357, the most infected cultivars (Tables 1 and 2), produce whips earlier and throughout the growing season. These whips protrude over the canopy of the cane. Newly infected buds gave rise to new whips. Smut was first observed in L72.85 and subsequently in CP65.357 and L62.96, which collectively account for 95% of the total hectareage grown. From 1993 to 1995, smut spread from L72.85 to CP65.357 and L62.96 as the areas infected and the incidence of smut increased during the same period. L72.85 was not commercially grown in the Moulouya region. The severity of smut as expressed by the number of whips observed per ha was very low in 1993 and rapidly increased to more than 5,000 whips per ha in 1995 (Figs. 2, 3, and 4). The increase was greater in L72.85 than in the other two cultivars.

Smut is an African disease; upon introduction into a country, it remains a permanent threat to the industry and has never been adequately suppressed. It flourishes in dry weather, which favors rapid shedding of spores from the whip (23). The appearance of smut in Morocco followed 2 years of severe drought and high temperatures, and coincided with a large increase in hectareage of L72.85, which was released to farmers in 1988. The spread of smut infection is affected by cultivar characteristics, environment, and cultural practices (12,

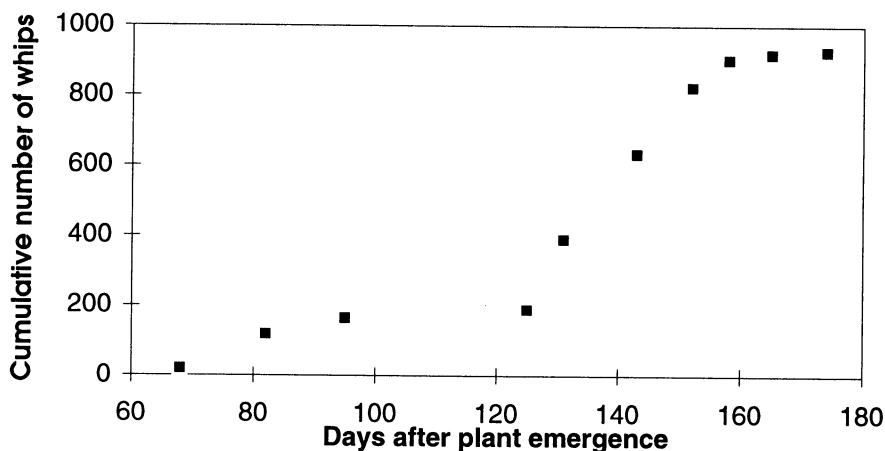


Fig. 1. Progress of smut in a planted sugarcane crop of cultivar L72.85 in the Gharb region of Morocco (May to August). Day 60 is 3 May.

Table 1. Incidence of smut infection on sugarcane in the Loukkous region of Morocco (1993 to 1995)

| Cultivar | Area inspected (ha) | | | Area infected with smut | | | | | |
|-----------------|---------------------|------|-------|-------------------------|------|------|-------|------|------|
| | | | | 1993 | | 1994 | | 1995 | |
| | 1993 | 1994 | 1995 | (ha) | % | (ha) | % | (ha) | % |
| L72.85 | 176 | 116 | 286 | 117 | 66.2 | 90 | 77.8 | 259 | 90.7 |
| L62.96 | 314 | 9 | 91 | 10 | 3.2 | 9 | 100.0 | 81 | 89.0 |
| CP65.357 | 503 | 108 | 640 | 10 | 2.0 | 28 | 26.6 | 424 | 66.3 |
| CP66.346 | 0 | 0 | 100 | ... | ... | ... | ... | 0 | 0.0 |
| Mixed cultivars | 17 | 56 | ... | 0 | 0.0 | 45 | 81.3 | ... | ... |
| Total | 1,011 | 288 | 1,117 | 137 | 13.5 | 172 | 59.8 | 765 | 68.5 |

Table 2. Incidence of smut infection on sugarcane in the Gharb region of Morocco (1993 to 1995)

| Cultivar | Area inspected (ha) | | | Area infected with smut (ha) | | | | | |
|-----------------|---------------------|--------|-------|------------------------------|------|-------|------|-------|------|
| | | | | 1993 | | 1994 | | 1995 | |
| | 1993 | 1994 | 1995 | (ha) | % | (ha) | % | (ha) | % |
| L72.85 | 2,142 | 2,093 | 1,634 | 645 | 30.1 | 586 | 28.0 | 940 | 57.5 |
| L62.96 | 2,696 | 3,406 | 3,670 | 149 | 5.5 | 186 | 5.4 | 1,117 | 30.4 |
| CP44.101 | 767 | 611 | 204 | 0 | 0.0 | 23 | 3.0 | 26 | 15.9 |
| CP65.357 | 3,101 | 5,162 | 4,112 | 169 | 5.5 | 601 | 11.6 | 1,320 | 32.1 |
| Mixed cultivars | 3,03 | 294 | 99 | 11 | 3.5 | 61 | 20.9 | 38 | 38.7 |
| Total | 9,009 | 11,566 | 9,719 | 974 | 11.8 | 1,457 | 12.6 | 3,442 | 35.4 |

16). It is suspected that smut first became established in Morocco on L72.85. This cultivar was dropped from the breeding program in Louisiana because of its high susceptibility to smut but was grown in Morocco because of its early ripening and high yields, and the absence of smut at the time of its introduction. New plantings from cuttings of L72.85 and CP65.357 were stopped in 1993 and 1994, respectively, in order not to increase unnecessarily the spread of smut. These cultivars produce many whips throughout the growing season even though their productivity was only slightly affected at the beginning of

the smut epidemics in the Gharb and Loukkous regions. However, the rapid increase of smut incidence since the disease was first detected, from less than 100 whips per ha in 1993 to more than 5,000 whips per ha in 1994, and over 10,000 whips per ha in some inland areas in 1995 (3), suggests that economic losses may be very great in the near future, as fields with an incidence greater than 5,000 whips per ha are recommended to be plowed following harvest to accelerate the replacement of susceptibles cultivars with resistant cultivars. The results of resistance tests conducted in Senegal, in anticipation of smut

infection (3), and in Morocco since 1993 (M. Akalach, unpublished data) indicated that L72.85 and CP65.357 have a rating of 7 to 9 (highly to very highly susceptible) on the Hutchinson scale (19). CP44.101 was also susceptible and to a lesser degree so was L62.96. It was then decided to multiply resistant cultivars CP61.37, CP70.321, and CP66.346 in greenhouses and under plastic tunnels, as possible replacements for susceptibles cultivars even though these cultivars are not as productive as L72.85 or CP65.357. These resistant cultivars will be released to farmers in fall 1996 in areas where L72.85, L62.96, and CP65.357 are heavily infected with smut. The use of resistant cultivars has been reported to effectively control smut spread and incidence (14,15). Until these new cultivars are established in Morocco, sanitation measures continue to be the only means available and currently implemented by the CTCS to reduce the impact of smut disease and avoid significant economic losses. These measures include the withdrawal of susceptible cultivars such as L72.85 and CP65.357 from cultivation, repeated roguing of infected fields, the destruction of heavily infected fields, reduction of physiological stress, and the establishment, maintenance, and close monitoring of smut-free nurseries through the use of hot water treatment at the CTCS.

The Moroccan sugarcane industry must live with smut in the years ahead and should continue implementing the necessary steps to ensure that smut-resistant cultivars are available to farmers. Smut is becoming a major problem where inoculum densities are high. Past research (10, 12) has clearly demonstrated that no single method is effective in controlling smut, and thus an integrated approach is essential to avoid losses. Unless sanitary measures that reduce the amount of inoculum are properly implemented, the future of not only L72.85 and CP65.357 but also other, less susceptible cultivars will be jeopardized.

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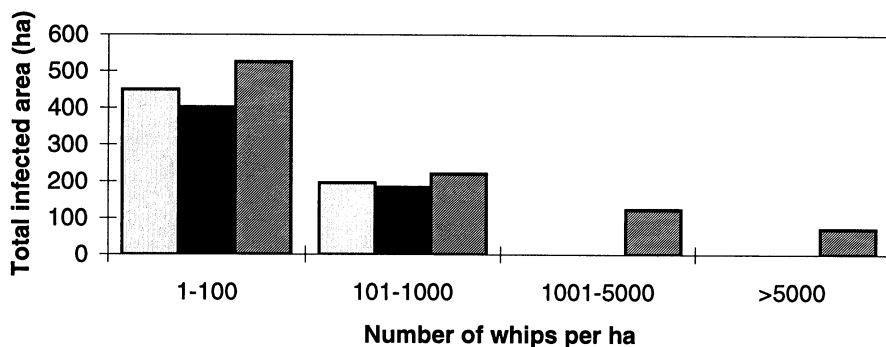


Fig. 2. Incidence of smut infection as expressed by the number of whips per ha in sugarcane cultivar L72.85 (1993 to 1995).

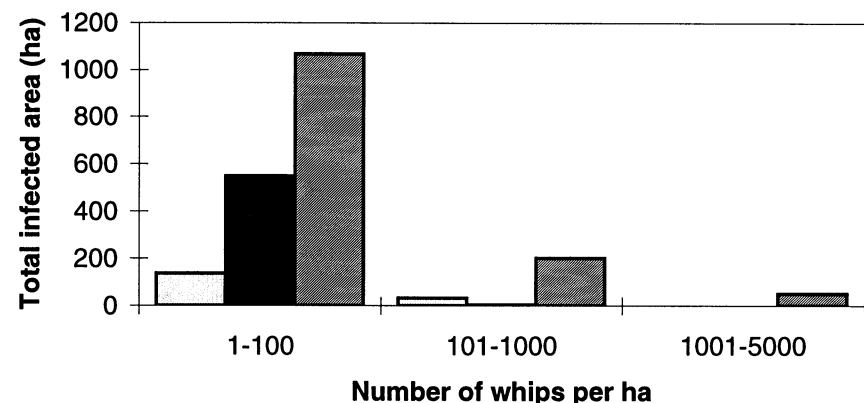


Fig. 3. Incidence of smut infection as expressed by the number of whips per ha in sugarcane cultivar CP65.357 (1993 to 1995).

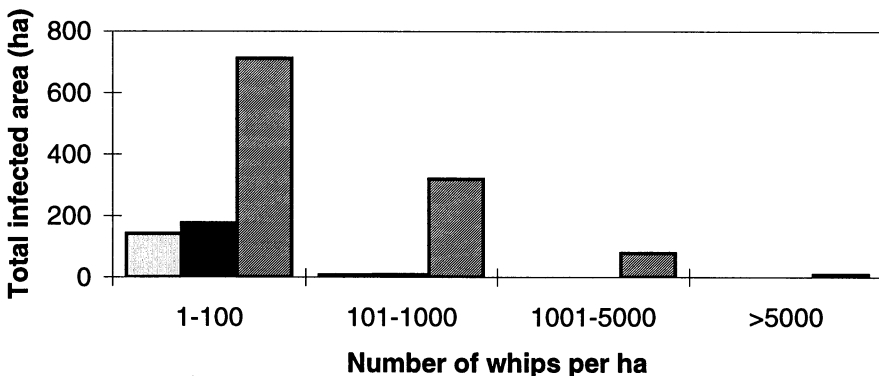


Fig. 4. Incidence of smut infection as expressed by the number of whips per ha in sugarcane cultivar L62.96 (1993 to 1995).

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