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Edited by
L. Jean Claude Autrey, A. Salem Saumtally,
Raul O. Castillo Torres and Peter G. Allsopp

The First 100 Years of the International Society of Sugar Cane Technologists

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Editors:

L. Jean Claude Autrey

A. Salem Saumtally

Raúl O. Castillo Torres

Peter G. Allsopp

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Réduit 80835
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Email: issct@intnet.mu

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Pathology 1950-1974

Philippe Rott

philippe.rott@cirad.fr

INTRODUCTION

Nine congresses (VII to XV) were held during 1950-1974 and 208 communications were presented in sugarcane pathology during this period. While only 11 communications were given in sugarcane pathology at the VII congress in Brisbane, Australia, this number rose to 33 at the XII congress in San Juan, Puerto Rico. These communications covered general reviews of diseases but foremost various aspects of 35 diseases, including economic importance, etiology, epidemiology, and control. Of the 208 communications, 39 covered sugarcane diseases in general, while the other ones covered specific diseases, with the three most investigated being ratoon stunting, mosaic, and red rot. These three diseases were the only ones that were, on average, the subject of at least two papers per congress. Fifteen communications focused on quarantine and exchange of plant material, especially in 1959 at the X Congress in Honolulu.

In addition to the congress presentations, ISSCT pathologists also produced the first comprehensive compendium in sugarcane pathology comprising two books *Sugar cane diseases of the world*. The first book (Volume I) was edited in 1961 by Martin and collaborators, and volume II was published three years later by Hughes *et al.* (1964). In 1968, ISSCT pathologists also produced the first issue of a newsletter to rapidly disseminate information on sugarcane diseases.

RESEARCH ADVANCES

Updates on known sugarcane diseases, description of new diseases and their geographical distribution

At the VII congress in 1950, Martin presented a paper entitled "Sugar cane diseases and their world distribution". Because references to the occurrence of diseases in some countries were not available or surveys were not conducted, this first list was rightly considered incomplete. Consequently, a resolution was adopted at the plenary session of the VII Congress to appoint a standing committee for the purpose of maintaining a list of all cane diseases of the world that would be reported at each future congress. A revised list was further discussed at the VIII congress in 1953 and revised listings were officially presented and published at the ISSCT congresses starting in 1956 until the early 1990s.

As mentioned in 1956, "Sugarcane diseases are not static….". "A current or up-to-date listing of sugar cane diseases and their world distribution is invaluable to countries in relation to interchange of varieties, disease control, and collecting expeditions, and also to universities and other scientific institutions." In 1962, a list of 74 sugarcane pathologists worldwide was also established to promote closer cooperation between them. Martin chaired the standing committee on sugarcane diseases until 1962 and Antoine (the 1962-1965 chair of this committee) outlined the outstanding contribution of Martin. A comprehensive list of sugarcane nematodes of the world, including more than 50 species and 13 genera was also presented at the XIII congress (Winchester 1968). The nematode fauna recorded in 1974 in Cuba comprised 124 species, 108 in the soil and 88 in sugarcane roots (Razjivin 1974).

Additionally, several new diseases or pathogenic variants of causal agents of known diseases were reported at the 1950-1974 congresses such as the first report of Sembur in Java (Hes 1953) and the first report of white leaf in Taiwan (Matsumoto 1969).

Ratoon stunting

With 32 communications, ratoon stunting disease or RSD was the most discussed disease at ISSCT congresses from 1950 to 1974. Initially considered as a specific disorder of sugarcane in 1944-1945, RSD was first recognized as a disease of this crop in Queensland, Australia in the late 1940s thanks to the investigations conducted by Steindl and was brought into prominence at the VII congress (1950). Besides a comprehensive description of symptoms of this new disease, Steindl reported the first mechanical transmission of RSD from diseased to healthy plants, which was strong evidence for the presence of a pathogen in cane juice. In addition to growth reduction, RSD was also identified by a yellow-orange to red coloration of the vascular bundles at the nodes of mature stalks and a diffuse salmon-pink discoloration of the nodal area in young shoots. These diagnostic symptoms were used for many years in Australia but also in other countries where the disease was found. However, these internal stalk discolorations were not always found satisfactory or reliable for the diagnosis of RSD or for testing resistance to the disease (Ricaud 1974; Steib 1974).

Steindl also performed the first hot-water treatment (HWT) assays to eliminate the pathogen in infected stalks or cuttings. After further improvement in several locations, HWT (2 hours at 50°C) soon after proved to be an efficient control method of RSD, which is nowadays still in use to combat the disease in numerous countries worldwide. Interestingly, as early as in the mid-1950s, plants showing RSD symptoms in quarantine in Taiwan were not destroyed as they could be rendered disease-free using HWT (Chu 1959). In 1954 in Taiwan, 18,421,272 two-bud seed cuttings were hot-water treated with mobile and stationary units and then used to plant 858 ha of nurseries (Chu 1959). Thanks to this control program that was carried out until 1959, the incidence of the disease was reduced in plantation farms from 60.6% (55/56 crop year) to 13.4% (66/67 crop year) with only 6.4% in 62/63 (Chu 1968). A treatment of seed cane for 8 hours at 58°C using a commercial hot air oven was used for the control of RSD in Louisiana since the late 1950s (Tantera 1971). Similarly, a hot-air seed cane treatment plant was developed in India for the elimination of both the RSD pathogen and the causal agent of grassy shoot (Menon 1971; Sandhu 1974). In the early 1970s in Australia, the standard practice was to soak entire sugarcane stalks in hot water for three hours at 50°C. About 3000 to 4000 t of cane were treated annually for the production of disease-free plots on a farm scale (Steindl 1974).

For a long time, RSD was considered to be caused by a virus for which resistant varieties were sought. Treating soil with bromoethane was thought to attenuate a soil-borne virus (Steib 1965) and a species of rabbit failed to transmit the RSD virus (Bourne 1965). At the XV congress in Durban (1974), Gillaspie and collaborators from the USA and Teakle from Australia, both reported the association of a small bacterium with RSD-affected sugarcane. This bacterium, currently known as *Leifsonia xyli* subsp. *xyli*, was indeed the causal agent of the disease. Because of its fastidious nature, it was successfully isolated in pure culture and checked for pathogenicity only 6 years later by Davis and collaborators.

Based on Steindl's description of RSD, the disease was also diagnosed in Louisiana in the early 1950s by Abbott, and later in Mauritius (Antoine 1959), Taiwan (Chu 1959), Hawaii (Martin 1959), Mexico (1959), Sri Lanka (Egan 1962), Réunion (Hoarau 1965), Dominican Republic (Liu 1965), Puerto Rico (Liu 1965), Mozambique (Rosario Noronha 1971), etc. As stated by Hughes in 1962 when summarizing three decades of sugar-cane pathology: "Perhaps the most interesting recent discovery in the whole realm of sugar-cane pathology is that of ratoon stunting disease. This insidious disease with its entire lack of specific, external symptoms, offered a possible explanation of the mysterious 'running-out' of varieties which has been such a feature of the cane scene for so many years." RSD was reported in 27 countries in 1961 (Martin *et al.* 1961) and in the early 2020s in more than 60 countries. In Australia, it was estimated to cause 10-30% yield losses (Hughes 1974). The highest yield losses were associated with diseased sugarcane subjected to water stress (Rossler 1974).

Mosaic

Mosaic was the second most discussed disease at ISSCT congresses between 1950 and 1974. Only two papers were presented on mosaic from 1950 to 1959, but this disease was the subject of 22 papers from 1962 to 1974. This phenomenon was largely due to the development of new strains of the virus and the breakdown of varieties previously considered resistant. In 1962, it was reported by Abbott and Todd that resistance to mosaic among clones of *S. spontaneum* was not as universal as previously thought. Screening sugarcane varieties and seedlings for resistance to mosaic by mechanical inoculation was performed in several countries (Dean 1965; Liu 1965; Kolobaev 1974). Replacement of susceptible varieties by resistant ones resulted in a great reduction of mosaic incidence and even eradication in commercial fields.

In Louisiana, identification of the spreading periods of SCMV suggested that control of mosaic could be improved by roguing of virus-infected stools of sugarcane at specific months of the year (Steib 1968). Serial heat treatments proved to be efficient in eliminating the virus from infected stalk cuttings (Benda 1971). This concept of repeated hot-water treatments was new as heat therapy of sugarcane against pathogens generally consisted of a unique exposure to a given temperature.

New grass hosts of sugarcane mosaic virus, such as *Stenotaphrum secundatum* which can be common around sugarcane fields, were identified (Nolla 1965). Reciprocal transmission of the virus between sugarcane and other grasses was also demonstrated (Forbes 1971). Elimination of weed host plants near sugarcane fields in Louisiana did, however, not result in a significant reduction of the spread of SCMV (Zummo 1968).

The occurrence of synergetic effects of mosaic and red rot on cane germination, sucrose content, and yield were highlighted in Louisiana where the two diseases sometimes occurred in the same plants (Koike 1974). When sugarcane plants of CP61-37 were affected by both mosaic and RSD, the yield reductions were higher than for each disease taken separately.

Three additional insects were identified as vectors of the sugarcane mosaic virus (Abbott and Charpentier 1962). Furthermore, it was first demonstrated that the corn-leaf aphid becomes rapidly viruliferous (within 5 minutes) after feeding on sugarcane infected by SCMV and that the virus was transmitted by these viruliferous insects within 15 minutes after feeding on healthy plants (Zummo 1965). Similarly, the sowthistle aphid (*Hyperomyzus lactucae*) acquired SCMV within 15 minutes of presence on infected plants and transmitted the virus within 15 minutes after being placed on virus-free sugarcane plants (Zummo 1968).

At the dawn of the serological diagnosis of plant pathogens, SCMV was purified from diseased plants, antisera against SCMV strains were produced, and serological tests were developed to diagnose sugarcane mosaic (Gillaspie 1971; Handojo 1971). The availability of laboratory diagnostic tools later proved to be essential for the detection of viruses and other pathogens in asymptomatic plants, especially in quarantine. Disappearance and reappearance of mosaic symptoms were shown to be affected by temperature (Perdomo 1968). Strain F of SCMV was first reported in India (Bhargava 1971). It should be noted that this strain would later be assigned to a new virus species, *Sugarcane streak mosaic virus*, the causal agent of streak mosaic. The first occurrence of SCMV strains L and M was described in Louisiana (Zummo 1974).

Red rot

Red rot was the third most discussed disease at ISSCT congresses from 1950 to 1974 with 18 communications. Although red rot is nowadays mainly a disease impacting commercial production of sugarcane in India and Pakistan, this disease was a serious disorder in several countries starting in 1925 (Singh 1956). In the 1950s, the use of resistant varieties in India was limited because of resistance breakdown after a certain period of cultivation (Kar 1956). Variation in pathogenicity was described between isolates of the red rot pathogen in India (Singh 1956). It was suggested to test sugarcane for resistance to red rot using a mixture of isolates of the fungus to improve the selection of resistant varieties (Abbott 1956). In contrast to India, red rot was no longer a major problem in Louisiana since the early 1950s as the growing of resistant varieties prevented the development of severe epidemics on the remaining commercial susceptible varieties (Abbott 1962). Nevertheless, fungicides were tested in Louisiana for the control of red rot (Anzalone 1971).

The degree of resistance of parents appeared to have little effect on the percentage of resistant seedlings in a progeny (Azab 1959). While red rot was mainly associated with germination failure of sugarcane cuttings, the disease was affecting standing crops in India, thus the need to develop other resistance screening methods (Srinivasan 1965). Different inoculation methods were developed to screen for red rot resistance, including the nodal infection method (spraying of fungal spores on nodes) and the plug inoculation method (puncturing of standing cane) (Kar 1974). Investigations into the disease cycle of the red rot pathogen in a sugarcane plant revealed that perithecial build-up in summer contributes to the fungal inoculum in the field (Sanchsz-Navarrete 1965).

Blossoming of methods to test and rank varieties for their resistance to diseases

Although planting resistant varieties was recognised by sugarcane technologists since the occurrence of the first disease epidemics like mosaic, Fiji disease (now called Fiji leaf gall), the initial identification of resistant clones relied on natural infections and observation of disease symptoms. Numerous artificial inoculation methods and experimental procedures were developed from 1950 to 1974 in locations worldwide for testing the reaction of sugarcane to major diseases (Antoine 1965; Anzalone 1965; Wismer 1965). These diseases included chlorotic streak (Egan 1965), downy mildew (Chu 1968), mosaic (Abbott *et al.* 1965), eye spot (Osada 1968; Wismer 1965), leaf scald (Egan 1965, 1968, 1971; Koike 1971; Wismer 1965), Fiji disease (Husain 1965, 1971; Daniels 1968), Pythium root rot (Koike 1965), red rot (Abbott 1965; Srinivasan 1965; Wismer 1965), RSD (Abbott 1965), smut (Byther 1974; Rivera 1965), and white leaf (Leu 1974).

In the 1960s, varieties approaching the commercial stages in Australia were tested on a pathology farm that was remote from cane-growing areas. These varieties were either artificially inoculated or exposed to diseased plants for natural infection. Although resistance to some diseases can be tested in specific trials, it was recommended to not underestimate the observation of disease reaction from the seedling stage to commercial production (Hughes 1965).

Breeding for resistance was considered not difficult when only one strain of a pathogen was present and when suitable resistant parents were available. Breeding was made more difficult by the breakdown of resistance to several diseases such as red rot, mosaic, and leaf scald, and the development of new strains of the pathogens. Martin (1965) published the first comprehensive list of commercial sugarcane varieties of the world and their resistance and susceptibility to major diseases. At the XIII congress in Taiwan, Hutchinson (1968) proposed a numerical system for disease resistance rating with 10 subdivisions ranging from 0 (= immune) to 9 (= highly susceptible). The major advantages of this new system were the prevention of language difficulties in interpreting shades of meaning and the production of data immediately available for statistical analysis.

Dissemination of knowledge under the auspices of ISSCT besides ISSCT congresses

Besides congress proceedings, additional literature was produced under the auspices of ISSCT. This literature includes the first two books on sugarcane pathology mentioned above but also the *Sugarcane Pathologists' Newsletter* (SPN). The first issue of the SPN was published in September 1968 and the goal of this newsletter was to disseminate information, usually short notes, to sugarcane pathologists and provide a forum for discussion of various topics on sugarcane diseases. The first issue edited by Hutchinson (CSR, Sydney, Australia) and Srinivasan (SBI, Coimbatore, India) also contained a list of an international collection of slides illustrating sugarcane diseases. Hutchinson in Australia maintained this collection of initially 139 colored transparencies. The supplement to SPN number 7 (November

1971) listed 215 color slides featuring many aspects of sugarcane pathology. Copies of slides were available from Hutchinson (up to 25 were supplied free of charge and additional slides were charged at cost, 25 cents each). The final issue of SPN was published in November 1982 (Number 29).

PROMINENT CONTRIBUTORS

The 208 communications presented at the ISSCT congresses from 1950 to 1974 were authored or coauthored by 180 people. Ten of these authors were associated with at least seven congress papers, namely E.V. Abbott, S.J.P. Chilton and R.J. Steib from Louisiana (USA), R. Antoine from Mauritius, B.T. Egan, C.G. Hughes, P.B. Hutchinson and D.R.L. Steindl from Australia, J.P. Martin and C.A. Wismer from Hawaii (USA). Among these, Abbott, Hughes and Steindl stand out as great scientists who made tremendous contributions to ISSCT and sugarcane pathology in general. They produced numerous and highly valuable writings for their local and international sugar communities.

While E.V. Abbott was superintendent at the US Sugarcane field Station in Houma, Louisiana, the mosaic virus-strain identification work in Louisiana was made under his direction. He identified new aphid vectors of sugarcane mosaic virus (1962). Abbott was a member of the ISSCT disease standing committee for several years and was an editor of the first two books on sugarcane diseases in which he authored 22 chapters.

C.G. Hughes (Australia) was chair of the pathology section in 1962 and in 1971. While he was holding this position, he organized each time a symposium on international exchange of varieties. Hughes was a member of the ISSCT disease standing committee for numerous years. He was also an editor of the first two books on sugarcane diseases in which he authored 15 chapters. The notable scientific achievements of Hughes (and Steindl below) include the elimination of gumming and downy mildew in Australia and the reduction of Fiji leaf gall (formerly Fiji disease) to low levels.

D.R.L. Steindl (Australia) was the first to describe bacterial mottle caused by *Pectobacterium chrysanthemi* (initially named *Pectobacterium carotovorum* var. *graminarum*) in Queensland, Australia in 1957. He was the first to propose a long hot-water treatment (presoak of 24 hours followed by 3 hours at 50°C) against *Xanthomonas albilineans* in infected sugarcane setts (Steindl 1971). Nevertheless, his most remembered work was his research on RSD. Steindl laid the foundation work for many discoveries on this disease that proved to be a major constraint to sugarcane production worldwide.

IMPACT OF THE RESEARCH

The major impact of the advancements in sugarcane pathology from 1950 to 1974 was the improved control of diseases that resulted in the reduction of the yield losses caused by these diseases. The screening of varieties for disease resistance in specific trials, setup of disease surveillance systems, application of newly developed fungicides, heat therapy, and production of clean seed in specific nurseries all contributed to this result. The sugarcane industry is highly dependent on disease-resistant varieties (Hutchinson 1971). Nevertheless, obtaining resistant varieties is a long-term goal, and other options are sometimes needed (Hughes 1950; Daniels 1971). The integrated disease management concept was developed in several countries, such as Australia, where varieties were no longer discarded because of their susceptibility to a disease but rather withheld from areas with high disease incidence (Steindl 1965). Although the first clean-seed scheme dates back to the beginning of the 20th century in Java, the discovery of RSD and its possible control using heat treatments resulted in the establishment of this approach in numerous countries where the disease was found. Later, clean-seed schemes were also promoted to control other diseases such as Fiji disease in Australia (Egan 1974).

In the 1950s the innovative concept of testing local varieties against diseases occurring only in foreign countries emerged. Hawaiian varieties were screened against Fiji disease and downy mildew in Fiji (Robinson 1956). Cane varieties of interest to Mauritius where Fiji disease does not exist were tested for their reaction to this disease in Madagascar (Wiehe 1962). This allowed the industry to be aware of the potential risk of growing susceptible varieties and to know which resistant varieties could be cultivated in case of the appearance of a specific new disease, thus limiting its impact. To limit the risk of introduction of new diseases, especially those spread by infected cuttings, more secure circulation of germplasm was promoted via quarantine systems. In all the 10 quarantine programs described at the 1959 congress, only visual inspections were performed to identify diseases, except the quarantine in Mauritius where latent mosaic infections in imported material were tested by spindle inoculations on a susceptible variety (Wiehe 1959). This was going to change during the next ISSCT era thanks to the development of serological diagnosis of pathogens and especially of viruses (Gillaspie 1971). Although biotechnologies did not have a major impact on the advancement of the sugarcane industry as is the case nowadays, it shall be noted that the 1950-1974 period witnessed the first use of molecular methods to better understand or control sugarcane diseases. Ultraviolet radiation was used to obtain mutants of the red rot pathogen (de Carvalho 1968) and gamma radiation was performed to obtain sterile males of the leafhopper vectoring Fiji disease (Ayub Husain 1968).

In addition to technical improvements, the sugarcane industry also benefited from better diffusion of knowledge. As stated by Hughes (1962) when summarizing three decades of sugarcane pathology: “In conclusion I should like to draw attention to an important ISSCT activity which I feel has not received the publicity it warrants. I refer to the two-volume work on sugar cane diseases of the world. Volume I was prepared….. These volumes will prove an invaluable source of reference for all connected with sugar cane….This ISSCT book will also prove of the greatest value to workers in crops other than sugar cane…. I feel that all ISSCT members should be aware of this book and of its value to laymen and scientists alike.”

1950-1974 was an intense period of disease descriptions, identification of causal agents, their geographical distribution, their transmission, and control. This includes a description of quarantine procedures in various countries to limit the risk of introducing diseases (and living pests) with imported setts or fuzz. During this period, quarantine procedures involved essentially visual observation of plants, which required a good knowledge of disease symptoms, and progressively hot water treatments to eliminate some pathogens (Gillaspie 1974). Consequently, the years 1950-1974 constitute a very rich period in sugarcane pathology, from new discoveries to successful extension work, including the production of extensive literature for ISSCT members. The most significant disease discovery is undoubtedly the description and transmission of RSD in Australia, which was subsequently followed by the detection of this disease in numerous sugarcane production areas worldwide. Hot air and hot water treatments were developed, thus providing the first very efficient method to limit the effect of RSD on sugarcane yields.

Finally, the following quotes by CG Hughes at the plenary session of the XIII Congress in 1968 may reflect the feelings of sugarcane pathologists and entomologists about their contribution in the 1960s to increasing sugarcane yields by disease and pest control: “The politics of disease control are no less tortuous than those of other brands!… Unless the correct measures are taken, there can be serious losses to diseases and pests. There are no great obvious gaps in our knowledge of the measures needed, but there are very serious gaps in the dissemination and application of our knowledge…. It is up to all concerned, whether they be cane breeders, farmers, millers, or makers of laws, to play their part. Awareness that a problem exists is the first step to its solution, the next step is to learn something about it.” One may wonder if these quotes are still relevant.

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