THE TWO GUMMING DISEASES OF SUGARCANE

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SUMMARY
A historical review of the discovery of gummosis in various cane sugar producing countries is given. It would appear that, although the first definite record of the disease dates back to 1869 in Brazil, gummosis was a major limiting factor to sugarcane cultivation as early as 1848 in Mauritius and perhaps even earlier in Réunion Island.

The evolution of the epiphytotics in Mauritius and Réunion is described; distinction being made between the earlier epidemic, named gummosis I, which prevailed in commercial plantation in both islands up to 1948, and the new one, named gummosis II, which broke out in Réunion in 1958 and in Mauritius in 1964. Attention is drawn to the reappearance of leaf chlorosis as an expression of systemic infection, a symptom which was encountered in the past, but had apparently disappeared in intervening years.

After the outbreak of the new epidemic in Réunion, it was important to find out whether the disease was due to a new strain of the bacterium. Strain differentiation studies on the pathogen were initiated in 1960. With the reappearance of gummosis in Mauritius in 1964, isolates were obtained from infected old noble canes in the variety collection and from newly infected, hitherto, resistant varieties, in commercial plantations. Comparative studies led to the conclusion that a new strain of Xanthomonas vasculorum was responsible for the second epidemic of gummosis in Mauritius.

Host reaction to the new strain of the pathogen, with reference to leaf chlorosis, systemic infection and yield losses are described. The postulate that gummosis could have been originally a disease of palms and had subsequently passed to the sugarcane is discussed in the light of more recent knowledge. It is concluded that there is no convincing evidence to support the theory.

Control measures applied in Mauritius since the beginning of the new epidemic are described. It is concluded that, as varieties resistant to both strains of the pathogen have been released and that susceptible varieties are being gradually replaced, the total area under resistant varieties having risen from 31% to 51% in less than three years, the situation is well in hand and the eradication of this major threat to the sugar industry can be once more envisaged with confidence.

HISTORICAL
Gumming disease of the sugarcane or Gummosis is caused by a bacterium (Xanthomonas vasculorum (Cobb) Dows.) described for the first time by Cobb in Australia in 1893. However, as early as 1869, long before the bacterial nature of the disease had been recognized, Dräbert described a malady of the cane characterized by an exudation of yellowish gum from the vascular bundles, a typical feature of gummosis. Hinton in 1886 reported similar symptoms exhibited by a disease which had appeared in Madeira 3 years earlier. Bonne in 1894 reported the presence of gummosis in Mauritius in several varieties including Lahaina*, at a time when probably all the

* Otaheiti, Bourbon, Cana blanca, Canne blanche, Calana, Louzier.
canes under cultivation were susceptible and he considered that the disease had been responsible for the replacement of the Bambou* cane over the past 15 years. The malady was recorded in Australia in 1893 (Cobb\(^{10}\)) and in Fiji in 1895 (North\(^{13}\)).

It has been suggested (Earle\(^{13}\)) that gummosis was brought into Mauritius in cane imported from Brazil and gained entry into Australia from Mauritius in the same way. However, Orian\(^{23}\) postulated that the disease could be originally one of palms and that sugarcane in Mauritius may have been infected by organisms from the native palm, *Dictyosperma album*. If the theory is accepted, then Mauritius would have been an important source of the disease. The question will be discussed further along.

During the 20th century gummosis was identified in several other countries including the West Indies, Colombia, Rhodesia, South Africa, Réunion and Madagascar (Antoine\(^{24}\)).

GUMMING DISEASE IN MAURITIUS AND REUNION ISLANDS

Gummosis I

Although the first positive identification of gummosis in Mauritius dates back to 1894 (Bonâme\(^{9}\)), it appears that the disease was probably present in the island before the middle of the 19th century. Indeed, Bojer\(^{9}\) and Rawson\(^{23}\) enquiring into an epidemic prevailing at the time (1848) in sugarcane plantations, report symptoms such as, *inter alia*, widespread withering of leaves particularly at the tips, partial or complete etiolation of the foliage of standing canes, the chlorotic areas being at times covered with rusty-red dots, chlorosis of young ratoons, distortion of the top as a result of the binding together of the leaf sheaths, and top rot. Also a coloured drawing** named: "maladie de la canne blanche", presumably made by Bojer and meant to illustrate his report, is good iconographic evidence of some of the symptoms described. It may be agreed that the above description could apply equally well to leaf scald, particularly as there is no mention of an exudation of yellowish gum. However, although the occasional occurrence of swollen or sprouted lateral buds following death of the growing point has been observed, a feature which is at times associated with gummosis as well, the characteristic profuse side-shooting induced by leaf scald is not recorded. Also, the fact that the disease was seen to prevail under all types of soil and climate, to spread like wild fire and, at least on one occasion, to have probably an aerial dissemination, would lead one to believe that the epidemic encountered at the time was gumming disease.

It should be noted that Rawson\(^{23}\) also mentions that the same disease had been encountered even earlier in Réunion. However, the first positive record of gummosis in that island dates back to 1932 (Kopp and D'Emmerez de Charmoy\(^{17}\)).

Up to 1930 the evolution of the disease followed more or less a similar pattern in Mauritius and Réunion as the same varieties were, on the whole, grown in the two islands. All the canes cultivated were probably susceptible, although to varying de-
degrees, to gummosis, with the popular Tannas in the susceptible but tolerant class. There were thus no signs of any tendency for the disease to become extinct. However, in 1931 the first resistance trials were established in Mauritius (Shepherd), with the object of eliminating all susceptible varieties from cultivation. Gradually, with the extension of the resistant B.H.10/12 and the production of several resistant Mauritian canes, more particularly M. 134/32, which at one time was to occupy over 92% of the total area under cane, the disease was brought under control and by 1948, with the elimination of the last Tanna canes, gummosis had been eradicated from commercial plantations in Mauritius (Fig. 1).

Fig. 1. Varietal replacement in the control of the two gummoses. Shaded: susceptible varieties; Unshaded: resistant varieties. (Adapted from: Wiehe, P. O. and R. Antoine.)

In Réunion, with the gradual replacement of the susceptible varieties by resistant POJ., Co. and R. canes and M. 134/32, the disease was brought under control there as well. However, gummosis was never eradicated as small foci of infection were being maintained by the Tanna cane grown as shade plant in vanilla plantations.

It should be noted that one of the symptoms of gummosis, namely the etiolation of the foliage, seems to have been commonly encountered, sometimes on a large scale, in earlier records of the disease. That symptom is probably responsible for the name “maladie blanche” being given to the disease in Mauritius. However, it may well be that the name has been confused with that of “maladie de la canne blanche”, “canne blanche” being a synonym of the Otaheiti or Bourbon cane. It is also true that the characteristic leaf striping associated with gummosis was described only in 1895 by Tyron. North places emphasis on the leaf streaks and summarily mentions the “white chlorotic leaves” on some young shoots produced by diseased setts, their widespread occurrence in young infected ratoons and in older crops “when the disease is severe and of long standing”. It would appear, however, that in later descriptions the etiolation of the foliage is not encountered or is extremely rare. That symptom had been rarely encountered up to 1964 in Mauritius, even in a highly susceptible cane such as the “noble” 55–1182, planted to provide infection in resistance trials,
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in severely infected varieties in the trials themselves and in the susceptible "noble" canes in the variety collection. The same observation is recorded in Réunion for approximately the same period, D'Emmerez even mentioning "total absence of chlorosis". The picture was, however, going to change all of a sudden in the two islands.

Gummosis II

In 1958, in Réunion, affected by two cyclones and a severe drought, gummosis suddenly appeared again in epidemic form. Varieties which had hitherto proved to be resistant to the disease had contracted infection and were showing high susceptibility. Thus M. 147/44, a leading variety in Mauritius, B. 34104, and the most popular cane in Réunion, R. 397, were all affected and showing severe and widespread white chlorosis of the leaves. It was also observed that the progeny derived from Co. 281 was susceptible. A survey conducted in Mauritius revealed that the 3 varieties were still showing high resistance in the island, a confirmation of the original rating obtained in resistance trials. Furthermore, the 13 varieties derived from Co. 281 which had been tested in resistance trials in Mauritius, had all been found to be resistant. Although it could not be ruled out that the abnormal environmental conditions which had prevailed in Réunion could have been conducive to the outbreak of the new epidemic, particularly in a country where small foci of infection were known to exist, yet, the totally different reactions of the same varieties in commercial plantations and in resistance trials in Mauritius could point as well to the possible existence of a different strain of the disease organism in Réunion. The sudden reappearance of the leaf chlorosis symptoms on a large scale was also perturbing. However, gummosis had been responsible for severe losses in the past and for the elimination of several commercial varieties. The established procedure of testing all promising varieties, locally bred and imported, in resistance trials and releasing for cultivation only those highly resistant to the disease had led to its total eradication from plantations in Mauritius for 11 years (1948-1958). It is evident that such an established policy is valid as long as only one strain of the disease organism exists in Mauritius since varieties released for commercial plantings are selected on the basis of their reaction to that particular strain of the disease organism. It was realized as early as 1958, just after the new outbreak of gummosis in Réunion, that if a new strain of the bacterium was involved "the accidental introduction of another one (strain) would mean the complete collapse of the vigilant work carried out over so many years" (Antoine).

It was therefore decided to find out whether a strain different from the Mauritian one existed in Réunion and, to that effect, experimental work on strain differentiation in Xanthomonas vasculorum started at first with the cooperation of the late Dr. W. J. Dowson of the Botany School of Cambridge University and was continued with that of Dr. A. C. Hayward, at the time of the Commonwealth Mycological Institute. It should be mentioned that, in 1956, before the outbreak of the epidemic in Réunion, Dr. P. O. Wiehe had obtained the cooperation of Dr. W. J. Dowson for studies on strain differentiation in bacterial pathogens of the sugarcane. Dr. Hayward came to Mauritius, at the invitation of the Mauritius Sugar Industry Research Institute in 1960, and the work was extended with the cooperation in the field of pathologists from Réunion, Madagascar and Natal, to a comparative study in the laboratory at the C.M.I. of the characteristics of collections of the pathogen of
gumming disease isolated from sugar cane in Rhodesia, Madagascar and Natal and from sugar cane and *Thysanolaena maxima* in Mauritius and Réunion. The findings will be discussed in detail further along. However, mention should be made here that one of Hayward’s broad conclusions was that the geographical races from Réunion and Mauritius differed in host reaction but not in physiological character.

In June 1964, after the occurrence of 2 cyclones early in the year, the characteristic leaf stripes associated with gummosis were observed in Mauritius in fields of a few varieties rated as highly resistant to the disease, a characteristic shared hitherto by all canes commercially grown in the island. It is fortunate that cooperative research on strain differentiation in bacterial pathogen of the sugarcane had been initiated since 1958, as the information already obtained proved most-invaluable in assessing at once the true nature of the new epidemic. It was therefore immediately suspected that another strain of the pathogen had either arisen through mutation of the old strain, still present in the cane variety collection and in the resistance trials, or had gained access to the island from Réunion, that country being only just over 100 miles away from Mauritius. A survey revealed that varietal reactions in the 2 islands were similar, an observation which would tend to support the latter view. Isolates of what were assumed to be 2 strains and termed “old” and “new” were obtained in pure culture, the assumption as to the existence of two strains being, at that time, based on differences in varietal reaction only.

THE CAUSAL ORGANISM

The outbreak of gummosis in Mauritius added new momentum to the studies already conducted by Hayward on whether differences in varietal reactions in the field could be correlated with cultural and physiological properties of the bacteria isolated from diseased plants.

Although the possible existence of strain variation in *Xanthomonas vasculorum* had been hinted at by various workers, evidence was being obtained for the first time to support the theory. Thus Hayward had postulated, before the outbreak of the new epidemic in Mauritius, that isolates from gummed plants in Mauritius, Réunion, Madagascar, Natal and Rhodesia, could be divided into 2 groups according to their cultural and physiological properties. On the one hand, isolates from Mauritius and Réunion on the above basis are indistinguishable. However, as they can be separated by their virulence and host range, they should be considered as geographical races differing in host reaction, but not in physiological character. On the other hand, isolates from Natal, Rhodesia and Madagascar are of a physiologic type differing from that occurring in Mauritius and Réunion.

Once isolates were obtained from canes affected by the “old” and the “new” gummosis, attempts were made to differentiate the suspected 2 strains. It was found that nearly all the cultural and physiological characteristics of the 2 strains were indistinguishable. Only 2 tests gave an indication that the organisms were not identical: the ability to liquefy gelatin and the rate of flow down slopes of Wilbrink agar. Furthermore, that difference in rate of flow was considerably more marked when the organisms were cultured on slopes of a medium containing triphenyl tetrazolium chloride. As a result the habit of growth of the 2 strains stood out in sharp contrast;
that of the “old” strain assuming a large convex to pulvinate, circular type of growth, whereas the “new” one grew thinly on the medium and gave a filiform growth after only 4-5 days. It was therefore assumed that such difference in cultural character was due to a difference in amount and viscosity of the extra-cellular polysaccharide slime produced. Further experimentation conducted by Ricaud has shown that the relative viscosity of the old strain was higher and the optical density lower than that of the new one. Also, isolates of the new strain, in marked contrast to the old, lost their viability very rapidly in slant cultures on Wilbrink agar, a feature which could perhaps be associated as well with the nature of the polysaccharide slime. Furthermore, after staining and observation under phase contrast, morphological differences were observed between the 2 strains.

The evidence put forward supports the view that strain differentiation exists in Xanthomonas vasculorum and that a new strain, which has appeared in Mauritius, is responsible for the recent epidemic of gumming disease in the island.

HOST REACTION

As already mentioned, one of the characteristic features of the new strain of the pathogen is the production of leaf chlorosis as a result of systemic infection. However, such etiolation of the foliage, although commonly widespread and intense, particularly in young ratoons, cannot be taken as an indication of higher virulence of the new strain, if ultimate death of millable stalks is to be taken as the criterion. It was assumed at first that, compared to the noble canes of the past, the more vigorous hybrids under cultivation, particularly M. 147/44, possessed the inherent property of being able to grow away from the disease if subsequent production of green leaves is to be taken as a sign of recovery. Yet, it is now realized that although leaf chlorosis results invariably from systemic infection, the presence and intensity of such chlorosis do not reflect in any way the degree of damage inside the stalk. Furthermore, systemic infection does not necessarily lead to etiolation of the foliage. It should be noted that as early as 1935, in his classical monograph, North recorded that the white leaves occur, frequently in profusion, “particularly in good growing showery weather... when there is a tendency for the cane to grow away from the disease”. Also, the worst effects of the disease, namely death of stalks through the blocking of the main water-conducting vessels of the vascular bundles, has never been observed since the outbreak of the new epidemic. Such a feature may be correlated with the actual nature of the new bacterial strain described earlier. Comparative studies on reactions of susceptible noble varieties of the past to old and new strains could elucidate this point.

Recovery from leaf chlorosis does not necessarily mean disappearance of the disease from the plant. Usually, stalks which have apparently recovered, still harbour the bacterium in gum pockets in the stalk, the site of such cavities corresponding more or less to the internodes in the vicinity of the point of attachment of the chlorotic leaves. The site of the gum pockets is located more frequently in the basal portion of the stalk. An interesting finding was that the cutting knife at harvest could thus be an important means of transmitting the disease, the source of primary contamination being provided by the gum pockets in the basal portion of the stalk.
as well as the cane top when heavy leaf striping is present, particularly in wet weather. Such infected young ratoons have been observed to be the starting point for secondary infection in neighbouring stools, plants with leaf stripping being usually concentrated around chlorotic plants. Infection by the cutting knife readily takes place when young suckers are inevitably cut at harvest time above the growing point.

A proportion of chlorotic young tillers, produced after systemic infection has taken place, usually die and may lead to a reduction in the number of stalks per stool. It has been shown that a highly significant drop in yield of 23.2% in sugar per arpent, obtained experimentally, could be correlated to a reduction in the number of millable stalks. On the other hand, systemic infection has not led to abundant production of gum within the stem, as encountered in the past, and no trouble has been experienced in the factories.

An analysis of the reaction of hybrid canes to old and new strains shows that a higher number of varieties tested are susceptible to the latter, an indication of greater infectivity of the pathogen but not necessarily associated with greater virulence. It appears also that Stevenson’s conclusions on group resistance in nobilized hybrids of sugarcane will have to be revised in order to have a better understanding of the inheritance of such resistance to gummosis.

**ALTERNATE HOSTS**

Orian isolated *Xanthomonas vasculorum* in Mauritius from naturally infected *Zea mays, Thysanolaena maxima, Dictyosperma album, Roystonea regia* and *Areca catechu*. As the record on maize is confined to one case only, that plant will not be considered in the present discussion on alternate hosts.

In his comparative study of the cultural and physiological characters of the isolates from the sugarcane, *Thysanolaena* and palm (*Dictyosperma album*), Orian, although he drew attention to the fact that the *Thysanolaena* pathogen seemed to belong to a strain of *Xanthomonas vasculorum* slightly different from the pathogens isolated from sugarcane and palm, did not give a separate taxonomic status to that organism.

Hayward in his studies on the differentiation of isolates of *X. vasculorum* confirmed Orian’s findings. He found that the sugarcane pathogen differed from the *Thysanolaena* isolate (both obtained in Mauritius) in their reaction on starch, casein and gelatin media. He concluded therefore that there were “two distinct populations of bacteria causing gummning disease on sugarcane in Mauritius and a disease on *T. maxima*”. He suggested that “under natural conditions the affinity of the *T. maxima* pathogen for sugarcane was low and likewise the affinity of the sugarcane strain for *T. maxima*, except under extreme climatic conditions”. This is supported by the fact that the only isolate of the *T. maxima* pathogen obtained by Antoine in Réunion, following cyclonic conditions, proved to be indistinguishable from the sugarcane pathogen.

The fact that Orian isolated from palms a bacterium closely similar to, if not identical, with the sugarcane pathogen is unquestionable. However, his contention that in Mauritius gummosis could have been originally a disease of palms, asks for
some comments. Orian isolated the pathogen from palms at a time when gumming disease was still being encountered, although on a very restricted scale, in commercial plantations. Also, although the native palm *Dictyosperma album* is grown on a fair scale in Mauritius for its edible cabbage, bud rot was but rarely encountered. The writer’s investigations between 1955 and 1967 have never revealed a single case of gummosis in native palms. Between 1955 and 1964 gummosis had been eradicated from commercial plantations of sugarcane and, had the disease been one of palms, one would have expected to detect occasionally a diseased tree. In spite of several cyclones which occurred between 1960 and 1964, and even after the disease had reappeared in sugarcane, no palm tree was ever infected. However, after the outbreak of the epidemic in Réunion, the writer while in that island drew attention to the typical yellowish gum which exuded from the vascular strands after splitting open a dying palm (*Roystonea regia*). It is unfortunate that the bacterium was not isolated from the diseased plant and comparative studies made with new and old strains of the sugarcane organism. From the foregoing observations it follows that there is no convincing evidence to conclude that gummosis was originally a disease of native palms in Mauritius.

**CONTROL MEASURES**

The first epidemic of gummosis was brought under control through the gradual replacement of susceptible by resistant canes. Between 1948 and 1963, the disease was totally eradicated from commercial plantations, although the pathogen was still present in the susceptible noble canes in the variety collection and in resistance trials. In 1964, gummosis reappeared in epidemic form and varieties grown over nearly 70% of the total area under cultivation, hitherto highly resistant, contracted severe infection. It was fortunate that the varieties still resistant could be extended to the various climatic zones of the island to replace the susceptible ones. The only problem was to produce a disease resistant, early maturing variety, adapted to the drier coastal areas of the island.

As it was immediately suspected that two strains of the pathogen were involved, isolates were obtained from newly infected varieties in commercial plantations and old noble canes in the collection and the bacteria considered as “new” and “old” strains. Through the development of a test, using a culture medium containing triphenyl tetrazolium chloride, the two strains could be easily differentiated. All promising varieties at various stages of selection which had been tested and had shown resistance to the old strain had to be re-tested immediately for resistance to the new one. Furthermore, it was decided to conduct trials for resistance to both strains separately during the course of selection. The problem of rapidly inoculating canes providing infection in large scale trials was solved through the development of an inoculation head adapted to a knapsack sprayer. It was thus possible to test the reactions of promising varieties to the new strain of the pathogen at an earlier stage of selection and to the old strain at the usual stage later. Thus between 1964 and 1966, the number of varieties tested amounted to 809 as compared to 1269 for the 31 years between 1932 and 1963. If, on the debit side, a few highly promising varieties had to be rejected, on the asset side, it was possible to release five resistant
varieties in 1966. Furthermore, several promising canes in the later stages of testing have shown resistance to both strains of the organism.

The replacement of susceptible varieties by resistant ones in commercial plantations has been gradual but steady. Thus the percentage area planted under the three highly susceptible canes, which had shown systemic infection, fell from 38% in 1963 to 2.5% in 1966, and in spite of the fact that a high number of iatroons is taken in Mauritius, the total area under resistant canes rose from 31% to 51% in less than 3 years (Fig. 1).

It follows that the situation posed by the reappearance of gummosis in Mauritius is now well in hand and that a second eradication of this major threat to the sugar industry can be envisaged with confidence. It can also be assumed that, in the meantime, the adverse effect upon the economy of the island will be at minimum, if any, given favourable environmental conditions.

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REFERENCES

12 Dranert, F. M. (1869) Bericht über die Krankheit des Zuckerrohres. Z. Parasitenkunde, 1: 13-17 (in NORTH, D. S., loc. cit. (1933)).
Discussion

J. W. Wilson: Does Dr. Wiehe consider that improvement in crop management would offset the need to replace a susceptible high-yielding variety?

P. O. Wiehe: Control based on crop management rather than resistant varieties can create serious problems. If planters maintain susceptible varieties, new varieties released later may succumb to the disease. For this reason only resistant varieties should be released. Field management could not achieve much towards inhibiting the dissemination of bacteria which are disseminated by wind and rain.

B. T. Egan: Gumming diseases not only induce poor yields but also cause trouble in the mill, this is due to polysaccharides produced in the stalks.

J. M. Gosnell: In Rhodesia, red stripe symptoms of gumming are prevalent on N:Co. 310 during the winter months (June-August). However, there is no development of gum in the stalk, even when the cane stands over to the following year. Can Dr. Wiehe differentiate between climatic conditions responsible for the leaf and for the stalk symptoms?

B. T. Egan: Many promising varieties are discarded because of their susceptibility to the disease.