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FORTY-TWO YEARS OF SUGAR CANE DISEASE RESEARCH AT THE LOUISIANA AGRICULTURAL EXPERIMENT STATION

A Report of Pathological and Botanical Investigations as They Have Affected the Louisiana Sugar Industry During the Period 1908-1950

By

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AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATION
W. G. TAGGART, Director
Forty-Two Years of Sugarcane Disease Research at the Louisiana Agricultural Experiment Station

A Report of Pathological and Botanical Investigations as They Have Affected the Louisiana Sugar Industry During the Period 1908-1950

C. W. Edgerton

Introduction

At this time when the writer of this report is retiring after 42 years of service from active participation and from any official connection with the sugar industry, it seems appropriate to discuss the role played by the Department of Botany, Bacteriology, and Plant Pathology of Louisiana State University and the Louisiana Agricultural Experiment Station in the development of the sugar industry, the activities in which the department has been interested during these many years, and to list some of the results obtained by members of the department. No attempt will be made to list all of the interesting and important investigations carried on by other departments of the University or of other agencies working on sugar problems in Louisiana. Consequently, this report will include mainly the results obtained from investigations carried on by the Department of Botany, Bacteriology, and Plant Pathology and other investigations only as they have had a bearing on the pathological and botanical work with sugarcane. There will also be included a discussion of the investigations which are still unfinished and of other problems which in the opinion of the writer should be investigated if the present level of sugar production is to be maintained.

This has been a very eventful period in the history of the Louisiana sugar industry, including a series of years in which the yearly production of sugar gradually decreased, a period of depression caused by crop failures between 1924 and 1927, and then a series of years in which the production gradually increased, reaching another peak in 1938. The trend since 1938 is still not
clear, but it is believed if something unforeseen does not happen, that, backed by the experience of the past and with the great amount of information gained by the research investigations, the high production of sugar can be maintained and perhaps increased.

Diseases have been considered to be the important factors in causing the low yields and crop failures, and consequently plant pathologists and botanists have taken a leading part in the investigations carried on with sugarcane. As nothing had been published about the diseases of sugarcane in Louisiana at the beginning of the period covered by this report, the plant pathologists had to start from scratch. Practically all of the information which is now available in regard to the diseases of sugarcane in Louisiana has been secured in this period. Much information has been obtained but still there is much more to be done. It is believed that a record at this time of the investigations which have been carried on and a discussion of the results will be valuable as a base for the "take-off" for those who are to follow.

It is hoped that this report will be of interest, not only to the technologists, but to all who are interested in sugarcane and the sugar industry in Louisiana.

Those to Whom Credit Is Due

During the period covered by this report, various members of the Experiment Station and Teaching Staffs in the Department of Botany, Bacteriology and Plant Pathology, and many graduate students have been interested in sugar problems. The progress which has been made is due to the combined work of all. The following have either carried on research projects or have assisted in the investigations.

Staff Members

H. R. Fulton
E. C. Tims
E. V. Abbott
L. H. Person
S. J. P. Chilton
R. T. Gibbens
Wm. J. Luke
E. R. Stamper
C. W. Edgerton
I. L. Forbes
T. C. Ryker
H. H. Flor
L. H. Flint
W. N. Christopher
P. H. Dunckelman
C. C. Moreland
P. J. Mills
C. F. Moreland
C. A. Brown
C. S. McCleskey
R. E. Atkinson
J. Dufrenoy

Graduate Students

F. J. LeBeau
W. E. Cooper
L. W. Faville
Ruth P. Phillips
R. Y. Nesom
M. L. Shaffer
Q. L. Holdeman
E. S. Hagood
C. S. Loh
Mrs. W. W. Hattox
F. Carvajal
R. J. Steib
L. E. Cowart
J. Guiscafre-Arrillaga
Fluctuations in Yield

In most countries where sugarcane has been grown on a commercial scale for a considerable period, history shows that fluctuations in the amount of sugar produced have occurred from time to time. These fluctuations have been of two kinds. First, there have been the variations from year to year, increases or decreases from the average due to temporary local conditions, fluctuations more or less similar to those occurring with other crops; second, there have been those which have extended over several or many years. The latter have usually been characterized by periods of rather long duration during which the production of sugar decreased rather constantly from year to year, or by periods during which production gradually or rapidly increased. Prosperity has usually accompanied the years with increasing production, while business stagnation, depressions and financial crises have frequently followed in the wake of low production.

Many factors are found to be concerned when an attempt is made to determine the cause of these fluctuations. Some of them are man-made, or at least influenced to a greater or lesser degree by man or man-made institutions, such as governments, sugar organizations, and research stations. Here may be classed such factors as wars, legislative acts in regard to tariffs, bounties and the like, inventions of new or improved machinery, and the general adoption of new methods of production based on information obtained by scientific research. Then, there are the so-called natural factors. Here, among others, should be included weather, climate, soil changes resulting from cultivation, and the attack of insect pests and diseases. Low yields caused by one or more of these natural factors have occurred at various times in a number of the important sugar-producing countries and in most cases, they have been very serious. However, the industry has usually survived and recovered and the results obtained by following programs based on scientific studies of the problems concerned have been remarkable and are landmarks in the history of the development of the sugar industry.

In the past, the crop failures which continued over a period of years were in most cases due to severe disease epidemics or epiphytotics, though in a few cases other factors, such as the attack of certain insect pests, were important, or, at least, contributed. Disease epidemics are much more apt to occur with sugarcane than with many other cultivated crops. Among the many reasons which might be listed to account for this, three seem particularly important. First, sugarcane, at least in the tropics, is in an active stage of growth during the entire twelve months of the year. This is very favorable for the dissemination and rapid increase of pathogenic
organisms which may be present. Second, sugarcane thrives best
where the rainfall, humidity and temperature are high. Such
conditions also favor the disease organisms. Third, sugarcane is propa-
gated vegetatively. All plants of a particular variety are genetically
identical. This means that all plants will be equally resistant or
susceptible to a particular parasite. If susceptible to a newly intro-
duced parasite, or to a new strain of an old one, or to one which
has been permitted to increase abnormally, all plants of the variety
will be attacked and the whole crop may be seriously injured. This,
unquestionably, is the most important of the three reasons.

It is interesting and instructive to trace the history of the
sugar industry in a region like Louisiana, to determine the extent
of the fluctuations in production from time to time and to find out,
if possible, the cause or causes of declining yields in certain periods.
It is also important to find out what measures were taken to bring
the industry out of depressions caused by such natural factors as
the attack of certain cane diseases. It will be found that history
has repeated itself to a certain extent. In general, the opinions of
growers during one depression have been similar to those expressed
at earlier periods and the recovery measures suggested and tried
at different times have had a great similarity. It will be found that
the recovery measures which were successful were usually based
on an extensive study of the industry and of the cane plant and its
adaptation to existing conditions.

Sugarcane was first introduced into Louisiana by the Jesuit
missionaries in 1751, though no extensive plantings were made for
some years later. The sugar industry itself did not really have its
beginning until after De Bore, in 1794, demonstrated that sugar
could be made successfully from the sugarcane plant in Louisiana.
After that event, the sugar industry, which of course includes the
growing of cane and the manufacture of sugar from the cane juice,
developed fairly rapidly. The sugar industry, then, has been in
existence in Louisiana for nearly 160 years, a time sufficiently
long for it to have felt the impact at one time or another of most
of the factors which influence sugar production. It can be expected
therefore that a study of the history of the industry will show
periods of declining yields, periods of depression, and periods dur-
ing which production was increasing. A knowledge of what hap-
pened in these different periods will bring out the importance of the
various factors affecting cane growth and the production of sugar,
and particularly of the natural factors associated with disease epi-
demics. This knowledge will also show the relation of scientific in-
vestigations to the problems of production and disease control and
will emphasize the necessity of continuing such work.

The fluctuations in yield and the depressions in the sugar in-
dustry that have occurred in Louisiana should probably be con-
sidered from two viewpoints. There are, first, the actual yearly variations in the total production of sugar in the State and, second, the average variations in the production of cane per acre. In the following discussion, these variations will be brought out by graphs accompanied by statements regarding the factors which are believed to have influenced sugar production.

The variations in the total yearly production of sugar in the State since 1860 are shown graphically in Figure 1. The graph shows two periods in which yields declined severely. One was at the time of the Civil War and is readily explained. The other began in about 1905 and reached its low point in 1926. There are also shown two periods in which production increased rapidly. One of these began in about 1877 and reached its peak in 1904, and the other started in 1927 and reached its peak in 1938. Within two of these periods, there were shorter periods in which production seemed to level off for a time. As shown in the graph, there were several years between 1914 and 1920 in which production seemed to be stationary. This was apparently due to high prices and increased demand for sugar during World War I. Even during these years, production did not rise towards the peak which had been reached in 1904. Again during the recovery period beginning in 1927 when the curve of production was rising, there was a short period between 1929 and 1933 when the production leveled off. During this period, the P.O.J. canes, which were then being grown,
were apparently producing at their peak. During these few years, the production of sugar in the State was at about the 1914 to 1920 level. With the general planting of the Co. and the C.P. canes, production again rose rapidly to the 1938 and 1939 peak.

In considering the prosperity of the sugar industry and the occurrences of depressions and recovery periods, it would seem that information on the average yield of cane per acre is as important as is information on the total production of sugar. A graph showing the production of cane per acre for the period between 1890 and 1950 is presented in Figure 2.

![Graph showing the annual yield of cane per acre in Tons, Louisiana, 1890 to 1949.](image)

**Fig. 2.—The Annual Yield of Cane per Acre in Tons, Louisiana, 1890 to 1949.**

There is a remarkable similarity in the curves representing total production and production of cane per acre. In Figure 2, the curve showing the production per acre rises to a peak in 1904, slowly declines to about 1914, levels off to about 1920, and then drops rapidly to the low point in 1926. In the recovery period that followed, beginning in 1927, the curve gradually rises to about 1929, levels off to about 1934, and then again rises to the 1938 and 1939 peak. In considering production in relation to the prosperity of the sugar industry, it may be that the production of cane and of sugar per acre is more important than is the total production.
Since 1938 and 1939, the total production and also the production of cane per acre have both been below the peak level.

The Industry and Pathology Research

It is generally recognized at the present time that the prosperity, or even the existence, of such an industry as the sugar industry depends upon technical knowledge obtained by extensive research along various lines. For centuries, the sugar industry merely existed. The growers in early time by trial and error or by unconscious selection used those canes which they found in their gardens or fields which seemed to do the best under their conditions. Much credit, however, is due these early growers. Starting with some prehistoric plant which apparently does not even exist at the present time, they were able, by unconscious selection through the centuries, to obtain such excellent, high-sucrose canes as the Bourbon, Cheribon, and other similar ones. As the industry of today has been built on these canes, it is much indebted to these early growers.

As the demand for sugar increased, greater acreages of cane were planted and the industry expanded into new lands. As a result, problems developed which were not solved by the slow, unconscious method of selecting satisfactory canes. Finally when the industry felt the impact of such diseases as the sereh in Java, the so-called rind disease in the West Indies, the red rot in India, and the root rot in many countries, something had to be done. This meant the establishment of Experiment Stations with men in charge who were sufficiently trained to investigate the various problems that were constantly arising.

In Louisiana, research on sugarcane problems may be said to have started with the establishment of a Sugar Experiment Station in 1885 with Dr. W. C. Stubbs in charge. After 1906, the research was slowly expanded to cover many lines of work. The great expansion in sugarcane investigations, however, has taken place in recent years following the failure of the industry in the 1924 to 1926 period. At the present time, the research with cane, which includes investigations in plant pathology, plant physiology, weed control, entomology, plant breeding, agronomy, soil technology, and agricultural engineering, is very extensive.

Research work in pathology began with the appointment of a pathologist in 1906 at the time when troubles in the fields were being reported by various planters. At that time, the industry was in a relatively prosperous condition. Most of the planters did not know anything about the diseases of cane and consequently the idea that diseases might become very important and eventually affect their way of life, never entered their minds. Also, to the Ex-
periment Station officials, sugarcane was only one of the important crops of Louisiana, and without any specific demands from the growers, there was no particular reason for stressing sugarcane investigations at the expense of other crops. For a time, and more particularly up to the period between 1919 and 1924, the investigations carried on by the one or two members then on the Staff were not confined to cane but were also concerned with many other crops, especially cotton and vegetable crops. The pathologist at that time was working under conditions which to a scientist seem almost ideal. His time was practically his own, and the investigations which he carried on were of his own choosing. The investigations on sugarcane at that time were largely on red rot and root rot. This was not because there was any particular demand on the part of the industry but because the problems with these diseases seemed to be particularly interesting and important to the pathologist. As it turned out, these diseases eventually came to be recognized as among the more important diseases in Louisiana. During this early period, much basic information was obtained which later was very useful.

Since 1924 the work in the Department of Botany, Bacteriology and Plant Pathology of the University and of the Department of Plant Pathology of the Experiment Station, due to a strong demand by the industry and with more funds for equipment and personnel, has expanded and extensive investigations have been carried on with diseases of cane and their control, the physiology of the sugarcane plant, studies of the organisms causing cane diseases, the role of soil organisms in cane culture, and in more recent years with sugarcane breeding and weed control problems.

**Progress and Results of Research**

In the following pages, there are presented chronologically the more important results obtained by the Staff members of the Department of Botany, Bacteriology and Plant Pathology, along with various events in the history of the industry which have influenced, or have seemed of interest to, the pathological work. This is strictly a report of the pathological and botanical investigations; space does not permit inclusion of the results of various other lines of research. This presentation should give to those interested a picture of the industry as it developed down through the years and an idea of the nature of the investigations that were carried on from year to year to meet the constantly changing problems.

The numbers in parentheses refer to the items in the list of publications at the end of this bulletin.

1820. Introduction into Louisiana of the Louisiana Purple and Louisiana Striped varieties. Previous to this date, the in-
Industry had depended upon the Creole, a variety which was unsatisfactory under Louisiana conditions.

1830. Introduction of the vacuum pan.

1844. Introduction of multiple effects which had been developed by Norbert Rillieux.

1852. Introduction of centrifugals.

1856. A very poor crop, only 41,231 tons as compared to 123,303 in 1855 and 154,047 in 1857. Because of unfavorable winter and spring conditions, the cane rotted very severely. The planters thought that the Louisiana cane had deteriorated and they induced Congress to send some warships to the tropics in order to bring back seed for a new start. Two ship-loads were brought back but the cane was placed in the holds of the vessels and heated so badly that it was dead before reaching Louisiana. However, with the return of normal seasons, the old cane came back and again produced satisfactory crops.

1862-1865. Civil war period. The industry was temporarily destroyed.

1872. After a series of poor years, Mr. La Pice was sent to Asia to bring back new cane. The cane he brought back was grown to a limited extent for a number of years. It was known in Louisiana as the La Pice cane but seems to have been the Crystalina, a cane that at the time was being grown very extensively in the tropics.

1885. The Louisiana Sugar Experiment Station was established with Dr. W. C. Stubbs in charge. The early work of the Station on cultivation, fertilizers, and the introduction of new varieties and the chemical investigations in the sugar house, were responsible for the rapid development of the sugar industry in the years that followed.

1890. Establishment by Dr. Stubbs of the Audubon Sugar School for the training of students in practical and scientific phases of sugarcane culture and sugar manufacture.

1892. Erection of the first nine-roller, single-engine mill in the State.

1893. The D. 74 and D. 95 varieties were introduced from Demerara by Dr. Stubbs. Seed cane of these varieties was distributed to planters four years later. The D. 74 became one of the leading varieties in the State.

1894-1897. Bounty on sugar repealed in 1894. Tariff of 1.95 restored on sugar in 1897.

1897. Organization of Louisiana Sugar Producers’ Association.

1899. A short crop. The coldest weather on record in Louisiana occurred in February, 1899.
1904. Largest crop on record up to that time, not surpassed until 1938.

1906. Sugarcane seed from the tropics was germinated in Louisiana by R. E. Blouin and A. E. Weller and seedlings were produced, the first time this had been done outside the tropics. During the following 11 years, 1842 seedlings were grown and tested.

1906. A short crop. Excepting the crop of 1899, which was affected by the cold, the 1906 crop was the first short crop since the introduction of the D. 74 variety.

1906-1908. Appointment of plant pathologists at the Louisiana Experiment Station to study the deterioration of cane that was believed to be occurring in the State. H. R. Fulton was appointed in 1906 and C. W. Edgerton in 1908.

1908. Fulton recognized and described the root rot of cane, listing the typical symptoms including the severe condition in which the stools could be easily pulled from the soil (1).

1908-1910. Red rot was found in State by Edgerton in 1908 (2). The rind disease and pineapple disease were reported two years later (3).

1911. Proof was presented that the red rot was reducing the sucrose content of cane in Louisiana (4).

1912. A short crop. This was influenced by the overflow of the river.

1913. The occurrence of the stem rot or Hawaiian "iliau" disease was reported by Edgerton (5). This disease caused some loss to the D. 95 variety.

1913. Underwood free sugar bill passed by Congress.

1914-1917. The importation of sugarcane seed into Louisiana was stopped owing to quarantine regulations of the Federal Horticultural Board. This, of course, stopped the production of new seedlings by the Experiment Station.

1914-1919. World war. Total production of sugar maintained by increased acreage in spite of declining yields.

1915. Another short crop.

1916-1920. Proof that the red rot was one of the important causes of poor stands of cane was presented by Edgerton and Moreland (6, 9).

1919. The mosaic disease was reported in the State by Edgerton (7, 8) and by Brandes (U. S. Dept. Agr. Dept. Bul. 829, 1919). At that time, the infection was largely confined to a few areas along the river.


1919-1920. Two years with short crops.
1921-1922. Two years with relatively large yields. In the years that followed, there was a consistent and rapid decline in sugar yields.

1922-1923. The Louisiana Experiment Station received 2500 seedlings and varieties from the U. S. Dept. of Agriculture. Among these were the varieties P.O.J. 36, P.O.J. 213, and P.O.J. 234. These canes were also received by the Sugar Station at Houma and by one of the large plantations. Testing of the new canes was pushed rapidly by the Experiment Station and by the Sugar Station at Houma.

1923-1926. Years with weather conditions extremely unfavorable for cane. The borer infestation was also very heavy.

1924. Practically a failure of the sugar crop. The worst drought on record occurred in Southern Louisiana with practically no rain during the whole summer and fall.

1924. More extensive investigations in Louisiana sugar production were started by the Louisiana Agricultural Experiment Station and the United States Department of Agriculture. A special appropriation was granted the Experiment Station by the State Legislature. Later, the United States Department of Agriculture received an increased appropriation for sugar work and the sugarcane breeding program was expanded at Canal Point, Florida.

1925. Proof was presented that the mosaic may appear and act differently even on the same variety. Selections were made of D. 74 and Purple canes that showed the disease in a very mild form. The evidence indicated that there was more than one strain of the virus involved (13).

1926-1927. Two years with very low production. The crop in 1926 was the smallest since 1864.

1926. Evidence was presented by McDonald of the U. S. Weather Bureau that weather conditions, particularly heavy rainfall and low temperature, during the winter months materially reduce cane yields (The Planter and Sugar Mfgr., May 29-July 17, 1926). This seems to be of particular importance when considered with the results obtained from the root rot investigations.

1927-1929. Evidence was submitted by Edgerton, Tims and Mills indicating that fungi of the genus Pythium were very important in the root rot problem in Louisiana (17, 21, 23).

1927-1930. Bacterial red stripe and mottle stripe diseases were reported from Louisiana and described by Edgerton and Christopher (20, 26).

1928-1931. General planting of the P.O.J. canes, the first step in the recovery from the depression.
1930. Presentation of proof by Flor that the fungus Pythium causes more injury during periods when the soil is cold and has a high moisture content, especially during the late winter and early spring (24, 25).

1930-1931. Severe epidemic of red rot in P.O.J. 213. It was necessary to abandon this variety and to substitute others. This variety occupied 35 percent of the sugarcane acreage in Louisiana in 1930.

1931. Proof presented by Tims and Edgerton that some varieties of cane recover at least from certain types of mosaic. This seemed to explain why certain varieties such as Co. 281 and P.O.J. 213 were at that time relatively free from mosaic (28).

1931. Studies on sugarcane roots by Ryker and Edgerton demonstrated the importance of protecting the roots by good soil preparation and shallow cultivation. County agents pushed recommendations made by the Experiment Station (27).

1931-1933. Two Coimbatore canes, Co. 281 and Co. 290, were released for general planting throughout the sugar belt. On account of the resistance of these canes at the time to red rot, stubble deterioration, and mosaic, they largely replaced the P.O.J. varieties. The general use of these canes constituted the second step in the recovery of the sugar industry in Louisiana.

1932. Proof was presented that there is more than one strain of mosaic attacking cane in Louisiana. A strain, apparently new to the State, attacked Co. 281 and some other varieties and rapidly spread over the sugar belt. Co. 281, which up to this time had remained practically free of mosaic, very quickly became one of the most susceptible varieties (29, 33).

1932. It was shown by Tims and Edgerton that all cultures of the red rot fungus do not show the same pathogenicity to different sugarcane varieties. The evidence, however, did not indicate that there were distinct, physiologic strains (30).

1932. An Actinomycete antagonistic to the root-rot Pythium was reported by Tims (31).

1933-1934. The Canal Point seedlings C.P. 28/11, C.P. 28/19, and C.P. 29/320 were released for general planting. All of these were very valuable for a number of years. The first two, however, gradually failed and were practically abandoned. On the other hand, the C.P. 29/320 remained a satisfactory cane and as late as 1950 was planted on a sizable acreage. The use of the Canal Point seedlings constituted the third step in the recovery of the sugar industry in Louisiana.

1933-1938. Data indicating that there are at least two distinct strains of the red rot fungus attacking varieties differently, were presented by Abbott of the Division of Sugar Plant In-

1934-1939. Based on extensive investigations, Summers of the Division of Sugar Plant Investigations reported the occurrence in the State of at least 10 distinct and recognizable strains of the mosaic virus (Phytopathology 24:1040-1042, 1934; and Proc. 6th Cong., Internat. Soc. Sugar Cane Technol., pp. 564-565. 1939.).

1934-1939. Attention was directed by Edgerton, Tims and Mills to stubble deterioration. Both root rot and red rot seemed to be involved. As poor-stubbling canes were considered dangerous, it was recommended that such canes not be released for planting (32, 41).

1934-1937. Jones-Costigan act was passed by the National Congress. This set up a quota system to regulate the amount of cane that could be grown and also provided for benefit payments to the growers. This was the beginning of the attempt by the National Government to regulate sugar production.

1937. The occurrence of chlorotic streak in the State was reported by Abbott of the Division of Sugar Plant Investigations (The Sugar Bulletin 16 (17):3-4. 1938; and also Phytopathology 28:855-857. 1938).

1937-1939. Investigations reported by Atkinson and Edgerton showed that spores of the red rot fungus migrate through the large ducts in the fibro-vascular bundles. In varieties such as Co. 281 with open ducts, the spores are able to migrate through several internodes, while with varieties such as C. P. 29/116 with cross walls in the ducts, the spores usually remain confined to a single internode (38, 40).

1938. The 6th Congress of the International Society of Sugar Cane Technologists held in Louisiana. Delegates from most of the sugar-producing countries were present.

1938-1939. Investigations by Shaffer demonstrated that it was possible by roguing to keep fields of the variety Co. 290 comparatively free of mosaic. As a result, this valuable variety was saved. Results with Co. 281 were not as successful (47, 48).

1938. Largest yield of sugar in Louisiana on record. This provided the peak in the ascending curve beginning in 1927, based on production of sugar.

1938-1946. Extensive investigations were carried on by various members of the department on the hot water treatment of seed cane. At the request of the American Sugar Cane
League, extensive field tests were made in various parts of the sugar belt during a five-year period. The hot water treatment eliminated the chlorotic streak virus from the seed cane and also stimulated the germination of the buds. Increased stands and increased yields up to three to four tons per acre were obtained (49, 52, 58, 64, 67, 70, 72).

1941-1948. Results of investigations indicating that losses from the cane borer could be reduced by dusting with cryolite and other poisons were presented by the Department of Entomology, Louisiana Agricultural Experiment Station, and by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. As the red rot fungus enters the cane stalk through borer channels, the control of the borer will also reduce the loss from red rot.

1942-1944. The perfect stage of the red rot fungus was found and described by Carvajal and Edgerton. The name of the fungus became Physalospora tucumanensis Speg. (62).

1943. As shown by Forbes, the mosaic virus disappears from plants that recover from mosaic (59).

1943-1944. As reported by Edgerton and Carvajal, infection by the red rot fungus can take place by infection threads from apressaria penetrating the uninjured epidermis (66).

1944. Resistance to red rot was shown to be closely associated with the formation of the red zone around the infected area. The mycelium of the red rot fungus does not penetrate this zone readily. Resistance to the disease depends on how rapidly the red zone forms. In resistant varieties, this zone forms very quickly (66).

1944-1947. A special appropriation by the State Legislature was made to the Louisiana Agricultural Experiment Station for the eradication of the alligator weed which was very troublesome in Louisiana sugar fields. Investigations by Brown, Carter, Holdeman and others, and by Arceneaux of the Division of Sugar Plant Investigations, U. S. Department of Agriculture, showed that this plant could be easily eradicated by spraying or dusting with 2,4-D. On most plantations, the weed was quickly brought under control (71, 73, 74, 75, 87, 88).

1945. It was shown by Forbes that the mosaic virus will move from a young plant through the old seed-piece in the ground to another plant (68).

1947. As shown by Steib and Chilton, infection by red rot in planted stalks takes place mainly through the bud scales and the old leaf scars. Most cane stalks are infected when planted, the red rot mycelium being in an inactive condition (77).
1947-1950. Based on investigations by Chilton, Stamper, and Ryker, considerable progress has been made towards the control of Johnson grass (89, 90, 91, 92, 96).

1947. As determined by Steib, Johnson grass seed produced in Louisiana germinates readily under the right conditions (84).

1947-1950. From investigations on seed-piece decays, Chilton found that a species of Phytophthora is one of the important organisms responsible for the rotting of seed cane in the soil during the winter months.

1947-1950. In a preliminary survey, Cooper found that certain Actinomycetes which are abundant in the soil are antibiotic to Pythium, one of the important root rot organisms (83, 95).

1948-1950. In order to increase the number of sugarcane seedlings, an extensive breeding project to supplement the work of the U. S. Department of Agriculture was started under the supervision of Chilton. From 70,000 to 80,000 seedlings have already been produced.

1949. The investigations of Phillips and Chilton indicate that there is an enormous amount of viable Johnson grass seed produced in sugarcane fields. This has emphasized the necessity of having satisfactory control measures for Johnson grass seedlings (93).

**Discussion**

Looking back over a long period of years during which the sugar industry, in its ups and downs, has been watched closely and during which intensive investigations have been carried on with problems which at the time seemed important, certain conclusions have been reached and certain ideas and theories have evolved which may be worthy of consideration.

The investigations in the department have mostly been concerned with disease problems, though in recent years considerable attention has been directed towards weed control and in obtaining information on the very important problems concerning the role played by organisms in the soil on soil fertility and on their relation to plant growth. The diseases which have received the most attention are the red rot, root rot and mosaic. These are considered to be the major cane diseases in Louisiana at the present time. The red rot has been studied for more than 40 years, and probably there is more basic information available concerning it than for any other cane disease caused by a parasitic organism. Much information has been obtained in regard to the life cycle of the organism, methods of infection, environmental conditions favoring the disease, and factors related to resistance. Varieties known to
be very susceptible have been abandoned and new seedlings are not released unless they show considerable resistance. As to the root rot, much valuable information has been obtained in regard to varietal resistance and the relation of the environmental factors favoring it. It is known that losses from root rot can be materially reduced by good drainage and by cultivation which does not injure the roots of the cane plants. There is evidence that severe losses are still occurring due to destruction of roots from cultivation. Much information has been obtained in regard to mosaic. This disease, however, has temporarily become of minor importance. With the exception of Co. 290, the susceptible varieties have been abandoned and new seedlings showing susceptibility are not released. Even if new strains of the virus should appear, it is believed that the susceptible varieties could be discarded before a serious situation developed. The minor cane diseases such as the bacterial stripe diseases, the Helminthosporium and Cercospora leaf spots, the pokkah boeng, the chlorotic streak and a few others have received considerable attention and their places in the general disease problem are fairly well understood.

As to the work of the future, there is still much to be done and there are still many problems awaiting solution. It may be useful at this time to focus attention on some of these problems and to present certain ideas and theories which have come to mind as a result of the many years of research. Some of the theories and ideas may be controversial, and so it should be said, using the words of the radio broadcaster that "the opinions are those of the speaker and not necessarily those of the Station." Nevertheless, it may be useful to keep them in mind as the problems of the industry, both old and new, are investigated in future years. Technologists, as well as others, are prone to accept as facts, ideas and theories which have been presented to explain some difficult problem but which are not based on reliable data. Progress may come, then, not only by the acquisition of new information but also by a willingness to question, and to discard if necessary, old accepted ideas and theories which are untenable.

**Cause of Depressions.** Depressions have occurred in the sugar industry at one time or another in practically every sugar-producing country. During these depressions, the yields of cane usually decreased from year to year, finally reaching the critical point when the returns were not sufficient to pay the costs of production.

Satisfactory explanations of the cause or causes of these depressions have not been given. As disease epidemics have in most cases been assumed to have been responsible, pathologists have had a leading role in the intensive investigations which have been responsible for the recovery of the industry. At one time or another,
various diseases have been held responsible for the poor growth of the cane during the depression periods. Among others may be mentioned the sereh in Java, the gummosis in Brazil, the rind disease and the red rot in the British West Indies, the red rot, root rot and mosaic in Argentina and Louisiana. Looking back, it is not possible to accept in toto the explanations which were current at the time of the various depressions or those which were presented later.

The depression in Java was the first one that was studied intensively by technologists. The poor growth of cane was said to have been due to the attack of a disease which was given the name sereh. This disease was often spoken of as the great mystery of the sugar industry. At the beginning of the depression, the sereh apparently included most of the diseases of cane which were present in Java. The early pathologists gradually separated from it such diseases as the red rot, the pineapple disease, the chlorotic streak, the leaf scald and others. When these were recognized as distinct, there was not much left. At the present time, it is doubtful whether there is anyone who would be willing to identify the sereh in the field. Consequently, the sereh is still the great mystery of the sugar industry.

The gummosis was first described from Brazil. That this was the cause of the trouble in Brazil from 1860 to 1870, has very generally been accepted by sugarcane technologists. However, as late as 1938, Bitancourt stated that “the identification of gummosis in Brazil is based on the symptoms of the disease, no proof having yet been given of its actually being caused by Bacterium vascularum (Cobb) Grieg-Smith, agent of gummosis in other countries” (Proc. 6th Cong., Internatl. Soc. Sugar Cane Technol., p. 190. 1939).

The rind disease was said to have caused the failure of the Bourbon cane in the West Indies in the period between 1890 and 1900. The fungus causing this disease is now known to be a very weak parasite and so could not have been responsible for the crop failures.

The red rot is world-wide in distribution and the claim has frequently been made that it was involved in certain crop failures, particularly in India, British West Indies and Louisiana. The fungus causing it is definitely parasitic and under the right circumstances causes severe losses, but the evidence is not sufficient to indicate that, by itself, it could continually over a period of years cause crop failures or even declining yields.

The term root rot is one which has been used very loosely to explain almost any growth failure. Many organisms have at one time or another been involved, but the evidence now available is not sufficient to show that any one of them is capable of causing crop failures year after year. Rather, the evidence seems to indicate that root rot, as the term is now used, includes a complex of pathologic,
physiologic and soil biologic factors, and it is still not possible to evaluate any one, either by itself or in the complex. It would seem that the statement made by Earle in 1920 that "there is probably no other plant disease of equal importance about which so little is really known and concerning which such erroneous ideas have long passed current in plant-disease literature" is still relatively true. To be sure, much valuable information has been obtained in regard to the organisms involved, the soil relations, and the adaptation and requirements of the sugarcane plant, but there still seem to be missing links. It is essential that the basic investigations be continued so that eventually some one may be able to evaluate all of the factors, including any new ones which may be recognized, and to put them together to form a true picture of the root rot problem.

It is not possible at the present time to explain satisfactorily the declining yields which occurred in Louisiana in the period between 1905 and 1920. Technologists have suggested that red rot and root rot may have been responsible for the trouble. These undoubtedly were important but how and why are not clear. The proper explanation of what happened during such periods would be of immense help to the technologists and to the industry of the future years.

Undoubtedly, the same factors which have been responsible for disease epidemics are also responsible for holding down the yields of cane in Louisiana. Yields of 60 tons per acre with Co. 290 and nearly as much with C. P. 29/320 have been obtained in the State. This shows the possibilities when all conditions are at the optimum. The average yields in the State, however, ordinarily vary from 19 to 21 tons. The spread between 20 tons and 60 tons is definitely too great. With more information in regard to root rot and other diseases, the activities of soil organisms, and physiology of the cane plant, it is not unreasonable to believe that average yields could be raised to 30 to 35 tons. It is, at least, a goal towards which the industry should strive.

**Deterioration of Varieties.** Cane varieties do not last indefinitely. Ordinarily, a variety will produce at its maximum for a few years and then the yields will begin to drop. Eventually, it is abandoned and other varieties are substituted. What is responsible for the deterioration of a variety is not clear. The plant physiologist is probably correct when he claims that a vegetatively-propagated variety will not by itself deteriorate. This means, then, that the factors responsible for the deterioration must be external. This means that certain organisms must become definitely specialized to that particular variety or that the soil conditions for some unexplained reason become less satisfactory for the growth of the plants. It is reasonable to believe that the same factors that have
been responsible for the depressions during the past centuries are also involved in the deterioration of individual varieties. It, however, is still not clear why a particular variety should rather suddenly become sensitive to one or more of these factors.

In Louisiana, the sugar industry experienced the deterioration of the Louisiana Purple and D. 74 canes in the period between 1905 and 1920. Since the depression, it has taken in stride the failure of such valuable and important varieties as P.O.J. 213, Co. 281, and C. P. 28/19. At the present time, Co. 290 is not as dependable as formerly and even C. P. 34/120 seems to be developing weaknesses which eventually may be dangerous. Of the recent important canes, C. P. 29/320 seems to be an exception as it has held up over a considerable number of years.

From a practical standpoint, the investigations have shown the necessity of being able to recognize when a variety begins to slip and to have other varieties ready to take its place. For the industry to continue in a prosperous condition, the production and the testing of new varieties must continue until much more is known about the factors responsible for the decreasing yields.

**Seed-cane Rots.** In Louisiana, the seed cane which is planted in the fall remains in the soil in a more or less inactive condition until the temperature begins to rise in the late winter and early spring. During this period, the cane is attacked by soil organisms of various types and many of the buds are destroyed or severely injured. On an average, only about 15 to 25 percent of the buds produce shoots. To take care of this loss, usually about two or more running stalks are planted. Even with this amount of seed, especially when soil conditions are not satisfactory, poor stands are not uncommon.

For years it has been known that red rot will cause poor stands, and recently it has been found that another fungus, a species of Phytophthora, will under some conditions destroy the seed cane. Investigations are now under way to determine if seed cane rots can be reduced by treating the cane at planting time with fungicides and by a more careful planting procedure.

**Antibiosis.** Many organisms in the soil secrete complex substances, known as antibiotics, which are toxic to other organisms. Some of these antibiotics, such as penicillin and streptomycin, have almost revolutionized the practice of medicine in recent years. Information in regard to the substances secreted by most of the soil fungi and bacteria is still very deficient. These substances definitely enable many organisms to survive in the soil in competition with other organisms.

These antibiotic-producing organisms unquestionably have an effect on the soil flora and indirectly on soil fertility. While it may
be assumed that some organisms which are desirable in the soil are eliminated, it has also been shown that certain pathogenic forms are also eliminated, or at least held in check; by these antibiotic organisms.

Some investigations have been under way in Louisiana on these antibiotic organisms. As early as 1932, it was shown that the growth of the root-rot Pythium was checked by a soil Actinomycete. Recently a preliminary survey was made of the Actinomycetes in the soil in the Sugar Belt. It was determined that many of them check the growth of Pythium. Such investigations should be continued and the scope expanded. The field is still unexplored and the possibilities are enormous.

Host-Parasite Relationships. For a better understanding of many of the diseases of cane, more basic information should be obtained in regard to the relations between host and parasite. A start has been made with the red rot and considerable information is now available in regard to how the fungus enters the host, how the fungus travels in the host tissues, and the reaction of the host cells. More information concerning host-parasite relationships should help the pathologist to work out better control measures and to make a start towards explaining the nature of resistance, probably the most complex but at the same time the most important problem in pathology. It is not unreasonable to hope that some of the questions regarding host-parasite relationships may be answered by using various radio-active substances as tracers.

Chemical Controls. During recent years, there has been great interest in the use of chemicals for controlling pests of various types, including insects, disease-producing organisms, and weeds. Investigations have been conducted on a large scale and unquestionably this work will continue to expand. The staff members of the Department of Botany, Bacteriology and Plant Pathology have been testing chemicals to control the various seed cane rots and to control weeds. The tests aimed at controlling Johnson grass have given such promising results that at the present time many growers are using chemicals to control this pest. Up to the present time, the investigations have been largely concerned with testing the chemicals that are being produced by various chemical companies. For the work to progress as it should, investigations should be started to determine how these chemicals affect the plants and the conditions under which they are active. The department recognizes the need of a trained physiologist and bio-chemist to carry on such work.

Many types of chemicals are presently being used. Some of these are merely contact poisons but others are hormone-like, growth-promoting substances. The hormones are extremely interesting, as they seem to act on the enzyme systems of the plants.
The study of hormones is one of the principal lines of work in the field of biology at the present time. The opportunities for obtaining interesting and valuable results are very great. Results with hormones may perhaps be speeded up by more extensive tests with radio-active tracers.

Before the work with chemicals proceeds too far, the technologists should determine what may be the effect of these substances on the soil. Little is known as to how these chemicals affect the soil or the soil flora. A microbiologist working on the soil flora and fauna might acquire information which would be of great value if troubles threaten in the future.

**Threats of New Diseases and New Virulent Strains of Parasites.** From a pathological standpoint, the sugar industry of Louisiana is still threatened from without and from within. There are a number of diseases in various parts of the world which have not as yet become established in Louisiana. Two of these, the smut in Argentina and Brazil and the leaf scald in Brazil, are relatively near. Others farther away include the downy mildew. Also in Queensland, pathologists are talking about a virus which checks growth of the cane and reduces the yield without producing visible symptoms on the plants. There are quarantines to keep such diseases out, but no quarantine is perfect and if a new disease should be introduced, it might cause considerable trouble until certain adjustments in regard to varieties and perhaps culture procedure could be made.

It is generally assumed at the present time that many lower organisms are not stable. New strains appear by mutation. It is also assumed that some of these new strains are more virulent than the old, parent strains, or are able to attack varieties which previously had appeared to be more or less resistant. Such new strains may become serious threats to the industry and may even make it necessary to discard very valuable varieties. These new strains are very confusing to the technologists but they must be recognized and studied.

**Sugarcane Breeding Possibilities.** The sugar industry of the world owes much to the early investigators in Java and India who found that it was possible to cross the Noble canes with the wild canes of the Pacific areas and to obtain varieties which were more vigorous and also more resistant or tolerant to some of the hazards which could not be eliminated by ordinary measures. In Louisiana, the recovery of the industry and its maintenance at the present level of production were made possible by the use of these hybrid canes, some of which were brought in from the Pacific areas and some of which were produced in this country. One of the major projects at the present time is the production of these new canes. Possibly 75,000 or more are being tested yearly in Louisiana.
The sugar industry, however, should recognize the limits of the cane breeding work. When two varieties are crossed, there is a recombination of the characters present in the parents. This has a certain similarity to the building of a new house with old materials. A wooden house may be torn down and the different pieces used to build a new house. These may be put together in a different way, but at the finish the new house is still a wooden structure. Again, if a wooden house and a brick house are torn down, a new house can be built of both brick and wood. After some experimentation and testing, a desirable combination of these two materials may be obtained. Beyond that, there is not much chance of improvement.

And so it is with sugarcane. When two varieties are crossed, the various factors of the two are recombined more or less by the law of chance. Most of the progeny are worthless because, except in a few, there is not a predominance of desirable characters. If, however, enough seedlings are grown, now and then, by the law of chance, one will be found that has a large portion of the desirable characters of each parent. After such seedlings are obtained, further improvement is slow. In other words, the production of better hybrids, provided the parents remain the same, seems to approach a limit. The experience in Louisiana has been about as would be expected. At first, the improvement was very rapid and in a very few years, a few very valuable canes such as C.P. 29/320 and C.P. 28/19 were secured. To improve on these from a production standpoint has not been easy. A few of the later canes such as C.P. 34/120 have in some ways been better, and some of the very recent canes seem promising. The number of canes, however, which have been released in recent years and have become important commercial canes has been relatively small. Of course, better canes, canes resistant to certain hazards, can and must be produced in the coming years.

Again, contrary to statements which have been made, there is no evidence to show that the present commercial canes from a production standpoint are better than were the old Noble canes such as D. 74 and Louisiana Purple in the period between 1890 and 1904. It may be admitted that statistics of that early period are not very reliable but they are probably accurate enough to show the situation at that time for comparison with that of the present time. As reported, yields of 27 tons per acre were obtained in 1890 and 26 tons in 1904. The nearest approach to this in recent years was 21.7 tons in 1938 and 21.96 tons in 1945. Of course, that is not the whole story. At the present time, D. 74 and Louisiana Purple are absolutely worthless and the new canes have the ability to make a satisfactory growth in spite of the various hazards.

Cane breeding at the present time seems to be very largely concerned with producing varieties that will produce satisfactorily
in spite of the known and unknown hazards. There is still much to be accomplished. Canes which are relatively resistant to the various diseases and also resistant to any new strains of any of the pathogenic organisms which may appear, must continue to be produced. Also technologists must strive to produce canes which are adapted to certain areas, canes which are better adapted to mechanical harvesting, canes which shade the soil and check weed growth, and canes with low fiber provided that they are also resistant to the various diseases. Canes must continue to come off the assembly line and be available to take the place of those that are failing. There is no question but what the breeding work must continue and also be expanded if the present level of production is to be maintained and raised.

There is, however, another angle to the production problem which should never be forgotten. There is little probability in the immediate future of producing a super cane that will continue to produce maximum crops indefinitely with a minimum of effort on the part of the growers. For a time, at least, growers must depend on varieties similar to those now in cultivation. The evidence indicates that any of the varieties which are now being grown commercially are capable of producing maximum yields if the various hazards are eliminated. Yields of 50 to 60 tons per acre have been obtained with Co. 290 and C.P. 29/320 and it may be assumed that the other varieties are capable of doing as well. This being the case, it may be that from a production standpoint more progress can be made by more extensive investigations on the nature of the hazards and by putting into practice measures, based on information which is at present available, aimed at eliminating or at least reducing the losses from these hazards.

To raise the production level, then, requires the work and cooperation of two groups, the technologists to find out more about the requirements of the sugarcane plant and of the hazards of growing the crop, and the planters to use more effectively the information available to make conditions in the field the most favorable for growth of the plant.

Summary

This is a brief summary of the work of the Department of Botany, Bacteriology and Plant Pathology on sugarcane and sugarcane disease problems during a period of 42 years. During this time in Louisiana there was a long period of declining yields, a depression, and a period during which yields increased. Practically all of the information now available concerning sugarcane diseases has been acquired during this period. All of the diseases have been
studied, but the three major diseases, red rot, root rot and mosaic, have received the most attention.

Other botanical problems which received attention include root development and root activities, the relation of the organisms in the soil to soil fertility and to parasitic organisms, production and testing of new cane seedlings, and weed control.

The problems which require intensive research in the immediate future are briefly discussed.

The More Important Publications of the Department of Botany, Bacteriology and Plant Pathology, Louisiana State University, on Sugarcane and Sugarcane Diseases, 1908-1950.

3. ____________ Some sugar cane diseases. La. Bul. 120. 1910.
4. ____________ The red rot of sugar cane. La. Bul. 133. 1911.
5. ____________ The stem rot or Hawaiian “iliau” disease of sugar cane. Phytopathology 3:93-98. 1913.
7. ____________ Mottling disease or mosaic of sugar cane. La. Planter and Sugar Mfgr. 62:397. 1919.


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74. __________, and __________. Alligator weed control in sugarcane with 2,4-D. The Sugar Journal 9 (8):2-4. 1947.
75. __________, and T. C. Ryker. The control of alligator weed in sugar cane and weeds in rice with 2,4-D. Down to Earth 2 (4):6-10. 1947.


