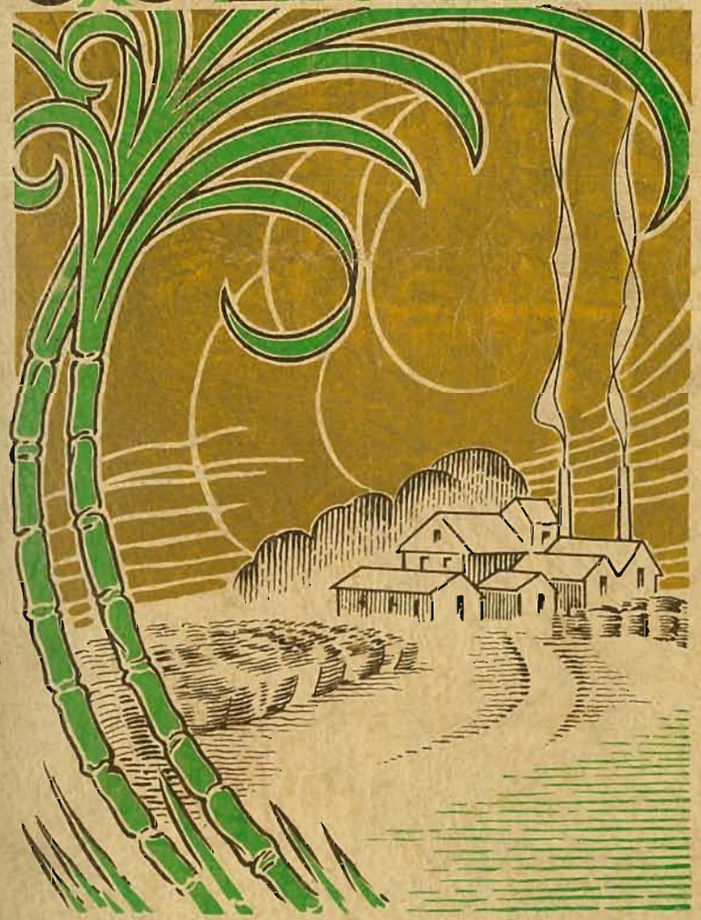
50 YEARS OF SCIENTIFIC PROGRESS



ADVISORY BOARD OF THE BUREAU OF SUGAR EXPERIMENT STATIONS.

★

Government Representatives	The Hon. H. H. COLLINS, Minister for Agriculture and Stock (Chairman) Mr. N. J. KING, Director of Sugar Experiment Stations.
Millers' Representatives	Mr. J. W. INVERARITY, Manager, Kalamia Estate. Mr. J. C. COLLIER, Manager, Amalgamated Sugar Mills Ltd.
Cane Growers' Representatives	Mr. L. G. SCOTNEY, Member of the Queensland Cane Growers' Council. Mr. W. POUSTIE, Member of the Queensland Cane Growers' Council.

STAFF OF THE BUREAU.

N. J. KING, Director.
L. G. VALLANCE, Assistant Director.

Division of Entomology and Pathology.

R. W. MUNGOMERY, Officer in Charge.
G. WILSON, Entomologist.
C. G. HUGHES, Pathologist.
D. R. L. STRINDL, Pathologist.
B. T. EGAN, Cadet Pathologist.

Division of Soils and Agriculture.

J. H. BUZACOTT, Senior Plant Breeder.
G. BATES, Senior Adviser, Meringa.
H. G. KNUST, Senior Adviser, Bundaberg.
G. A. CHRISTIE, Senior Adviser, Ayr.
C. G. STORY, Senior Adviser, Mackay.
S. O. SKINNER, Senior Adviser, Innisfail.
W. R. STERN, Assistant Agronomist.
J. C. SKINNER, Student Geneticist.
N. MCD. SMITH, Adviser.
O. W. D. MYATT, Adviser
E. V. HUMPHRY, Experimentalist.
E. A. PEMBROKE, Adviser.
N. G. GRAFF, Cadet.
J. ANDERSON, Cadet.
A. A. MATTHEWS, Cadet.

L. C. HOME, Analyst.
G. BIESKE, Analyst.
K. C. LEVERINGTON, Analyst.
J. R. BURGE, Cadet.
W. SOPER, Laboratory Assistant.
F. C. LINDSAY, Laboratory Assistant.

Division of Mill Technology.

J. H. NICKLIN, Senior Technologist. (Engineer).
J. L. CLAYTON, Senior Mill Technologist.
D. L. MCBRYDE, Assistant Mill Technologist.
C. B. VENTON, Assistant Mill Technologist.
L. R. BRAIN, Assistant Mill Technologist.
B. G. ADKINS, Assistant Mill Technologist.
A. D. DOOLAN, Technical Assistant.
A. G. CLAIRE, Assistant Mill Technologist.
K. J. YORE, Assistant Engineer.

Clerical Staff.

C. C. HORNE, Senior Clerk.
S. C. LEDDY, Clerk.
Miss M L. CHALLENOR, Clerk-Typiste.
Miss K. M. CARROLL, Clerk-Typiste.
Miss J. SEARLE, Clerk-Typiste.
Miss C. DODGSON, Clerk-Typiste.
Miss F. M. DOOLAN, Clerk-Typiste.
Miss M. D. SIEMON, Librarian.

FOREWORD.

★

The celebration of the Golden Jubilee of the foundation of the Bureau of Sugar Experiment Stations is an important event, not only in the annals of the sugar industry but in those of Australian agriculture as well. Perhaps only at this distance can we fully appreciate the foresight and sagacity of those leaders who, before the turn of the last century, advocated and planned an organisation which was to weld science and industry so early and so effectively.

The activities of the Bureau fall naturally into two distinct periods of about twenty-five years each. Beginning in what must now be regarded as the early morning mists of scientific agriculture, the first period was predominantly one of exploratory observation and recording, the assessment of problems, and the development of facilities. The second period was characterised by the recruitment of highly-trained staff, the initiation of researches inspired by the knowledge previously gained, and the organisation of comprehensive extension services.

Technical progress in the sugar industry during the second period was notable: Cultural and fertilizer practices were rationalised on the basis of many field experiments; losses from the world's most serious aggregation of sugar cane diseases were reduced to near-insignificance; the major insect pests were brought under satisfactory control; cane-breeding was revived and already more than half the crop is produced from Queensland-bred canes; manufacturing processes were transformed from traditional to technically devised and controlled practices. During this period, and in spite of the serious disruption caused by the war, production and recovery of sugar per acre increased by 50 per cent.

As is commonly the lot of successful organisations, the Bureau has experienced the compliment and disabilities of becoming a training and recruiting ground for other phases of endeavour. During the past 25 years only four members of the staff have passed through the age of 50 in the service of the Bureau, while throughout its history only one officer has retired under the statutory age limit provisions!

The policies and direction of the Bureau and the Industry it serves have always been closely integrated, and the continuance of relations on this high plane will ensure future success. Much has been achieved but much remains to be done. In the words of Sir William Whetham—

"But beyond the bright searchlight of science,
Out of sight of the windows of sense,
Old riddles still bid us defiance,
Old questions of Why and of Whence."

ARTHUR F. BELL, Under Secretary.

BUREAU OF SUGAR EXPERIMENT STATIONS.

FIFTY YEARS OF SCIENTIFIC PROGRESS

A Historical Review of the Half Century since the foundation of the Bureau of Sugar Experiment Stations.

Issued by direction of the
Hon. H. H. COLLINS, Minister for Agriculture and Stock.

A. H. TUCKER, Government Printer, Brisbane.

CONTENTS

★

The Foundation and Development of the Bureau of Sugar Experiment Stations.

By NORMAN J. KING.

INTRODUCTION.

Considering the age of some of the world's cane sugar industries Sugar Experiment Stations are a relatively recent development and Queensland was not very far behind some of the earliest; it was certainly much in advance of others. The first Sugar Experiment Stations created were those of Louisiana and Java, both of which began activities in 1885. Hawaii followed ten years later, St. Kitts in 1899, and Queensland in 1900. Argentine, Puerto Rico, and Trinidad inaugurated similar institutions in 1907, 1910, and 1911 respectively, and in 1925 Cuba followed suit. Two years later both Peru and Natal Experiment Stations came into being, and Mauritius Sugar Cane Research Station started up in 1930.

There is some degree of satisfaction in the knowledge that a short thirty-seven years after the start of the sugar industry in Queensland both the industry and the Government realized the benefits which could accrue from scientific research. The sugar producers of this State can also, with justification, be proud of the fact that theirs was the first agricultural industry in Australia to possess its own research organization. From small beginnings the Bureau of Sugar Experiment Stations has become a powerful factor in the technical advancement of the industry, and is, year by year, making progressively greater contributions to the efficiency of both agricultural and factory operations.

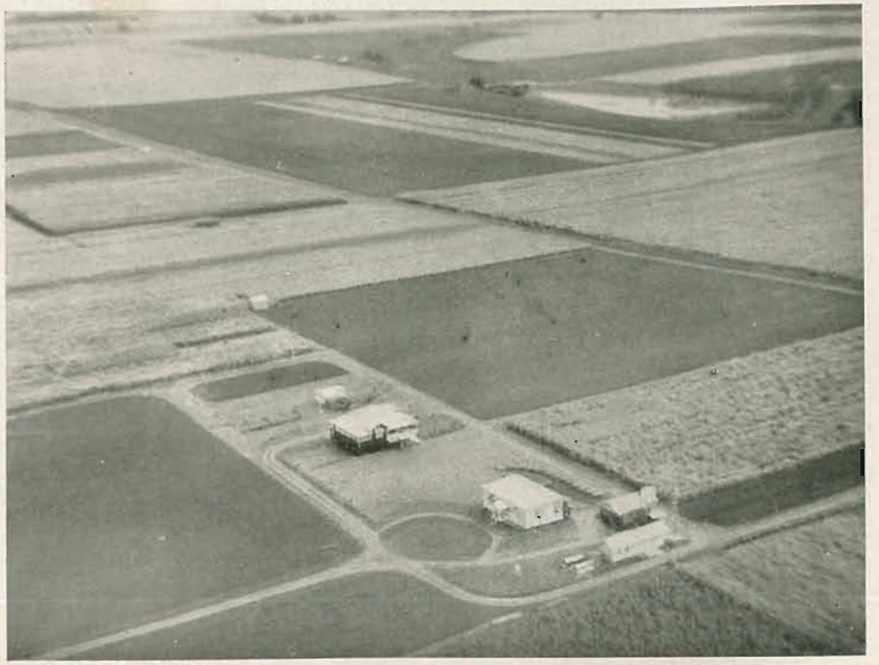
The Bureau, in 1950, completes its first half century of service to the Queensland sugar industry and looks forward to a further period of service to the producers and manufacturers who have, by their continued support, acknowledged the advances made.

EARLY HISTORY.

Although the Bureau of Sugar Experiment Stations began its official existence with the assent to "*The Sugar Experiment Stations Act of* 1900," which was given on 14th December of that year, many negotiations of historical and industrial interest predated that event. As early as 1885 the then Under Secretary for Agriculture (Mr. Peter McLean) investigated the necessity for establishing experimental farms or test stations, and as a result of his enquiries he advocated two State Nurseries at The Lagoons, Mackay, and Kamerunga, near Cairns, to be used for sugar cane and other tropical crops. By 1889 the Mackay Nursery was established and that at Kamerunga followed it two years later. These nurseries functioned to the advantage of the industry for several years, and both the Cowley and Tryon cane collections were grown at, and distributed from, those centres. By 1894, however, the industry was dissatisfied with the nurseries because of the lack of scientific investigation into soils and cane varieties, and an agitation developed for sugar experiment stations and laboratories along the lines of certain overseas sugar cane producing countries.

Both Henry Tryon, Government Entomologist and Pathologist, and J. C. Brunnich, Agricultural Chemist, were warm supporters of the scheme, and official notice of the industry's requirements was indicated by a statement by the then Minister for Agriculture, the Hon. A. J. Thynne, M.L.C., that he proposed to add a laboratory to the State Nursery at Mackay. This was erected in 1898 in accordance with plans drawn up by J. C. Brunnich. A. A. Ramsay, later chemist to the New South Wales Department of Agriculture, was the first chemist in charge.

This development appeased only temporarily the growers' oft-repeated requests for full scale sugar experiment stations, and in the next year it was announced that the State Nursery would be done away with and the site used on a more satisfactory basis as a Sugar Experiment Station. At the same time sugar growers approached the Government to invite Dr.



Mackay Sugar Experiment Station during developmental period.

Walter Maxwell, then Director of the Sugar Experiment Station of the Hawaiian Sugar Planters' Association, to visit Queensland to advise on the industry, the initial steps being taken by the Bundaberg Planters' and Farmers' Association. Dr. Maxwell was accordingly invited by the Government to undertake an examination of the industry and he arrived in Queensland on 9th December, 1899.

As a result of his report on the industry and on the essentiality of establishing sugar experiment stations, the Cabinet in March, 1900, wrote to Dr. Maxwell asking him to transfer his services to this State and offering him the position of Director at a salary of £3,000 per annum. This offer was accepted and Dr. Maxwell arrived to take up his new appointment in November of that year. "*The Sugar Experiment Stations Act of* 1900," which was passed in the following month, provided, *inter alia,* for the establishment and control of Sugar Experiment Stations, the appointment of a Director, and the creation of a Sugar Fund.

In his earlier report to the Government Dr. Maxwell, in outlining a desirable scheme, suggested that three experiment stations should be established—one at Mulgrave, one at Mackay, and the third at Bundaberg—the last mentioned to be the headquarters of the Director and of the main laboratory and chemical staff. On his appointment, the existing station and laboratory at Mackay became one of the planned units in the chain, and operations were put in hand immediately to construct the main laboratory and headquarters at Bundaberg. This building, which was opened in August, 1901, occupied the site of what is now the Lands Department building on the bank of the Burnett River and remained as the central laboratory of the Bureau until 1910. H. T. Easterby was Assistant Director in charge of the Mackay Sugar Experiment Station from the beginning of operations, while the first chemists engaged at the central laboratory were Firman Thompson, who returned to the United States in 1902, Dr. A. J. Gibson,

G. R. Patten, C. H. O'Brien, and A. E. Anderssen. A. R. Henry, who later became Secretary of the Central Cane Prices Board, was the Secretary of the Bureau at that time.

Between 1900 and 1909 this remained the administrative headquarters and laboratory of the Bureau while the Mackay Station was used for the basic investigational work on varietal testing, manurial trials, cultivation experiments, &c. A system of canegrowers' substations was inaugurated—stretching from Mossman to Nerang—and these served for the conduct of experimental trials on a wide range of subjects and under the varying soil and climatic conditions of the State. Dr. Maxwell severed his connection with the Bureau in March, 1909, and thus did not see his original plan of a chain of experiment stations come to fruition.

The Bureau of Sugar Experiment Stations now came, for the first time, into direct relationship with the Department of Agriculture and Stock, the then Under Secretary, E. G. Scriven, being also Director of the Bureau. In the following year, 1910, H. T. Easterby resigned to take up a position in the beet sugar industry in Victoria, and was succeeded by A. J. Gibson, who served for twenty-one months as General Superintendent. Easterby returned to the Bureau at this time and remained until his death in 1932. In 1921 he became Director, and during his long period of office saw the Bureau develop into a potent factor in the scientific progress of the sugar industry.

ENTOMOLOGICAL RESEARCH BEGINS.

In 1911 the initial steps were taken in entomological research with the appointment of A. A. Girault as entomologist at Nelson (now Gordonvale) in North Queensland. The white grub of the greyback beetle was the worst scourge of the industry in that locality and growers had agitated for some time for the appointment of an entomologist to study the pest and to evolve control measures. This appointment was the modest beginning of the entomological division of the Bureau, which in 1917 moved to its present site at Meringa and which by that time consisted of Dr. J. F. Illingworth, E. Jarvis, A. A. Girault, and A. P. Dodd.

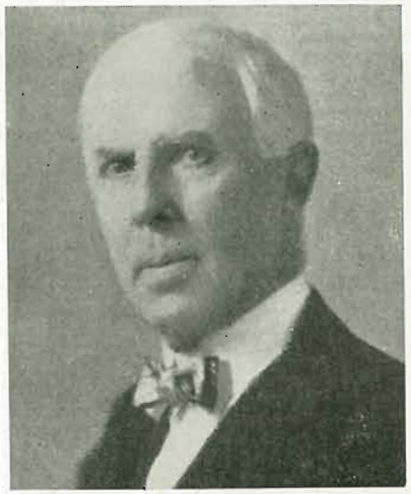
The period since the inauguration of this division has been marked by a vast amount of investigational work into pest control problems, but always with a heavy emphasis on the "greyback" grub. Subsequent upon Dr. Illingworth's return to America in 1921 E. Jarvis assumed control of the entomological activities and continued to direct the work until 1934. During those years his assistants included R. W. Mungomery, J. H. Buzacott, W. A. McDougall, W. Cottrell-Dormer, G. Bates, A. N. Burns, and J. E. Murcott. R. W. Mungomery took over from Jarvis in 1934 and during the following year visited Hawaii to study the habits and economic importance of the giant American toad (Bufo marinus) prior to arranging the importation of a colony into Queensland. He later became officer in charge of the Division of Entomology and Pathology. G. Wilson was appointed an Entomologist in this Division when J. H. Buzacott became Senior Cane Breeder.

There is perhaps no more spectacular example of industry progress as the direct result of research than the control of the "greyback" grub and wireworm pests in Queensland. The remarkable success achieved by the correct use of benzene hexachloride will be remembered as a major event in our agricultural history.

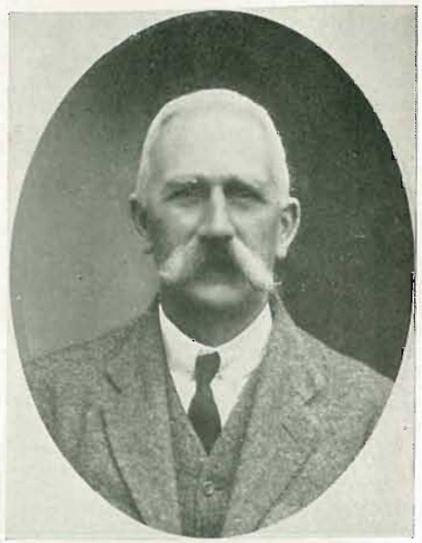
THE BUNDABERG EXPERIMENT STATION.

The year 1913 witnessed the acquirement of a further property at Bundaberg for a Southern Sugar Experiment Station and thus a further link was welded in the chain originally planned. This property was purchased as a going concern, having previously been a cane farm, and it was considered at that time to be ideally situated for an experiment station. In later years a laboratory and office building was constructed and this was followed by a glasshouse and necessary seedling equipment, as well as an irrigation plant and all essential farm buildings. By reason of the fact that the Bundaberg station was larger than

DIRECTORS OF THE BUREAU OF SUGAR EXPERIMENT STATIONS — 1900 — — 1950



Dr. W. MAXWELL—Director, 1900-1909.



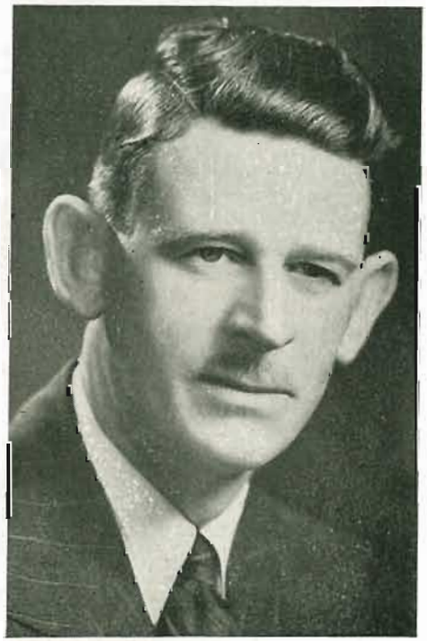
Mr. E. G. SCRIVEN—Director, 1909-1921.

Dr. A. J. GIBSON—General Superintendent, 1910-1912.

Mr. HARRY T. EASTERBY, General Superintendent, 1912-19. Director, 1921-1932.

Dr. H. W. KERR—Director, 1933-1943.

Mr. ARTHUR F. BELL, Acting Director, 1943-1945. Director, 1945-1947.



Mr. E. R. BEHNE—Director, 1947-1948.

Mr. NORMAN J. KING—Director, 1948 to date.

the original Mackay one and comprised a fairly uniform area of an important soil type, the major quantity of the Bureau's field investigational work was centred there. Practically every phase of fertilizer usage, liming, cultivation, green manuring, and soil moisture relationships have been enquired into and a host of other subjects have been experimented with to a greater or lesser degree. As from August, 1912, Bundaberg was the headquarters of the Bureau, but before long the General Superintendent transferred his office to Brisbane, which has since been the administrative headquarters. The first officer in charge at Bundaberg was J. Pringle who had been Assistant Chemist since 1908, and he was followed in 1937 by the writer, and in 1948 by H. G. Knust, the present occupant. As from 1926 an entomological laboratory and insectary were established on the Bundaberg station, with R. W. Mungomery in charge, for the purpose of studying and developing control measures against the southern district cane pests.

SOUTH JOHNSTONE EXPERIMENT STATION INAUGURATED.

In 1917 it was decided to complete the original plan of three experiment stations by establishing the third unit in the tropical north. A site at South Johnstone, at the foot of the Basilisk was chosen and consisted of average quality land of a type common to many North Queensland districts. Buildings, including laboratories and offices were erected, and the first officer in charge was P. H. McWalters who remained in that position until his retirement in 1927. In 1934 the station, then in charge of E. J. Barke, was transferred to Meringa, near Gordonvale, which had since 1917 been the headquarters of the Bureau's entomological research. It was felt that the northern operations of the Bureau could be rendered more effective by co-ordinating all services through one station and that the cane-breeding, entomological, and general agricultural work could be performed efficiently at Meringa. Up-to-date laboratories were constructed and equipped for the performance of all analytical work, a large glasshouse for seedling production was erected, and land cleared for the field experimental studies.

MACKAY EXPERIMENT STATION IS MOVED.

At about the same time it was thought that the Mackay station should be moved to a more suitable site. The old station, the starting point of the Bureau work, was a difficult location for field experiments due to irregularities in soil and to restriction in acreage. Expansion of activities demanded more room and eventually an area of land, part of the Palms Estate, was purchased—some 70 acres in extent and typical of the average lands of the Pioneer Valley. The buildings were transferred to the new site, a glasshouse and other buildings added, an irrigation plant installed, and the land suitably subdivided and graded for field experiments. After H. T. Easterby left the Mackay Station in 1910 the work at that centre was successively in the charge of L. C. McCready from 1910 to 1917, J. L. Foran to 1919, F. Keogh to 1935, D. L. McBryde to 1946, and C. G. Story to date.

In 1928 an entomological laboratory was established at this station to investigate wire-worm and grub pests which were causing serious losses. W. A. McDougall was appointed to the district in 1931 as Assistant Entomologist, and carried out studies and investigations into control measures until his transfer to the Department of Agriculture in 1948.

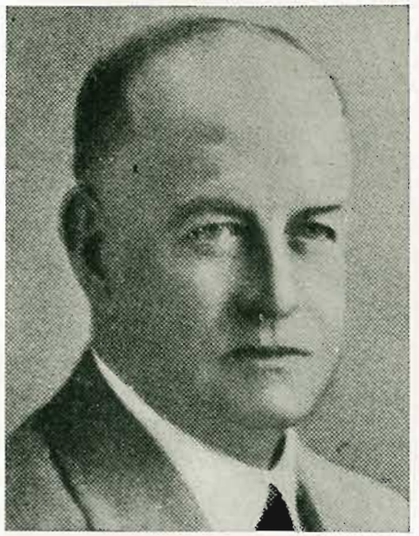
Between the years 1900 and 1931 the Bureau therefore expanded its activities from having one Sugar Experiment Station and one soils laboratory to three Experiment Stations, one entomological station, two entomological laboratories, as well as the administrative offices and laboratories in Brisbane. Although the original plan was now complete it was felt that one further experiment station was required in the Lower Burdekin area. The area is extensively irrigated and is climatically different from the rest of the sugar belt. It was considered, with justification, that its peculiar problems could not be investigated effectively by a single extension officer and that Experiment Station research was necessary. Accordingly, an area of land was purchased in 1948 and during the past two years developmental work has been proceeding. The first cane plantings were made this year. With an area of 90 acres it is hoped that this station will become an important one in the Bureau network and that its contribution to local cane production will be of value.

Part of Sugar Experiment Station at Meringa.

MILL TECHNOLOGY DIVISION IS CREATED.

In 1929 was established the Division of Mill Technology with N. Bennett as Sugar Technologist. Although originally located at Mackay, with laboratories at the Sugar Experiment Station, it was found desirable, on the resignation of Bennett in 1932, to transfer the Division to Brisbane, where suitable headquarters existed. Between this date and 1935 the sugar technology work was carried on by E. R. Behne and D. L. McBryde and in the latter year Ir. J. Eigenhuis was appointed for three years as Engineer Technologist. At the same time N. Smith joined the Division but resigned in 1937. Successive appointments were those of G. H. Jenkins, A. H. Praeger, and J. L. Clayton. Ir. Eigenhuis resigned in 1938 and he was succeeded as Mill Technologist by E. R. Behne. During and subsequent to the war years several staff changes took place including the elevation of Behne to the successive positions of Assistant Director and Director; in 1948 he resigned to join a sugar milling company. In 1945, J. H. Nicklin was appointed as Engineer to the Division and subsequently J. L. Clayton was made Senior Mill Technologist with six assistants in the persons of C. B. Venton, D. L. McBryde, L. R. Brain, R. G. Adkins, A. D. Doolan, and A. Claire. An assistant engineer was added in 1950. These nine members are the present personnel of the Mill Technology Division. The work of this Division was so intimately connected with milling and manufacturing problems that exceptional interest was evinced by the milling side of the industry in the details of opera-

tion and in the projects to be undertaken. Accordingly, in 1936, an informal meeting of milling representatives resulted in the formation of a Mill Research Programme Committee which would meet annually and consider a programme of research for the Bureau Mill Technology Division in the ensuing season. This committee, consisting of nominated representatives from each mill, has since that time met each year to discuss with Bureau staff the desired mill research work, and the programme laid down at these meetings becomes the subject matter for investigation.



Mr. A. R. HENRY—Secretary, 1902-1915.

SOILS LABORATORY.

Reference was made above to the transfer of Bureau headquarters from Bundaberg to Brisbane. Until the approximate date of this change the Bundaberg soils laboratory had, in conjunction with the Mackay laboratory, handled very large numbers of soil and water analyses for the Queensland canegrowers. In 1911, however, it was decided to carry out this important phase of the Bureau's work in Brisbane where better facilities existed, and to allow the Mackay laboratory to concentrate on sugar cane analyses. Accordingly, G. R. Patten and J. Pringle who had been on the chemical staff since 1902 were transferred to Brisbane where they continued to carry on the work in the laboratories of the Agricultural Chemist. In 1914 C. R. von Stieglitz was appointed to the staff but in the following year G. R. Patten was transferred to the Agricultural Chemist's branch, while J. Pringle returned to Bundaberg to take charge of the Sugar Experiment Station. From this time until 1930 the Bureau soils work was carried out in the Agricultural Laboratory, but in that year new administrative officers and laboratories were built for the Bureau in the main Agriculture and Stock building. C. R. von Stieglitz was Analyst in charge and N. G. Cassidy was appointed as Research Assistant in 1930.

During the ensuing fifteen years soil and plant nutrition studies formed the major part of the work of this branch and in the same period analytical laboratories were equipped at both Meringa and Bundaberg stations. The work carried out was closely associated with field studies and emphasis was at all times laid on correlation of laboratory results with replicated field trials. In 1945 a departmental reorganization resulted in C. R. von Stieglitz transferring to the Agricultural Chemist's Branch and the appointment of L. G. Vallance as Chemist to take control of this section. At the present time the staff comprises L. C Home, K. C. Leverington, G. C. Bieske, and J. R. Burge, the laboratory work still being directed by Mr. Vallance, who is now Assistant Director.

FIELD ADVISORY SERVICES.

As distinct from the development of Sugar Experiment Stations with their technical staffs, direct contact with the canegrowers has been maintained by field advisory staff since the early years of the Bureau. During the period of Dr. Walter Maxwell's administration a definite emphasis was placed on soil analysis and the contacts with farmers were, in the main, connected with soil sampling and related advisory duties. It was not until 1912 that a start was made to appoint field instructors, but within two years H. T. Harvey and H. G. Burn were located in the north and south respectively, their duty being to give general advice to canegrowers on any problem associated with sugar cane agriculture. Harvey died in 1915 and was replaced by A. P. Gibson, and Burn, who resigned in the same year was replaced later by J. C. Murray. In 1921 E. H. Osborn joined the field staff. A few years later W. Cottrell-Dormer, the first cadet pathologist, began field studies of certain of the major cane diseases and in the period 1925-1926 he was joined by E. J. Ferguson Wood, N. L. Kelly, and G. Wilson.

The establishment of the Pathology Division was followed by several staff changes, and by 1934 none of the cadet pathologists mentioned above remained with the Bureau. C. G. Hughes was appointed in 1934 and D. R. L. Steindl in the following year, and at the present time these two pathologists are responsible for the disease control work. W. D. Gibbons was appointed as cadet pathologist in 1944 but was replaced three years later by B. T. Egan.

In 1929 when the reorganization of the Bureau took place G. Bates was transferred from the Entomological to the Agricultural Divison and assumed responsibility for carrying out all field trials in the far north. Between 1933 and 1936 G. A. Christie, C. G. Story, S. O. Skinner, and H. G. Knust joined the field staff, and from 1939 to 1941 further appointments included N. McD. Smith, J. T. Elliott, E. V. Humphry, R. A. Abbott, and E. A. Pembroke.

This staff is responsible for the carrying out of the field experimental programme of work (as distinct from Sugar Experiment Station work) and for handling the extension and advisory work of the Bureau.

The outbreak of war witnessed the enlistment of practically all of this staff. Fortunately all returned. Certain staff losses and promotions in later years necessitated further recruitments and within the past five years O. W. D. Myatt, J. H. Barrett, P. J. Cheetham, N. G. Graff, W. Stern, J. Anderson and A. A. Matthews have been added to the

Field day at Meringa Sugar Experiment Station. Visitors are listening to an address by a member of the Bureau staff.

number. Barrett and Cheetham have since been transferred to other branches of the Department of Agriculture.

The geographical extent of the Queensland sugar industry makes necessary the presence of resident field officers at several centres not served by Experiment Stations. The above-mentioned staff members are accordingly stationed in the Cairns, Ayr, Mackay and Bundaberg districts where the Experiment Stations are their headquarters, and also at Innisfail and Nambour, where district work is sufficiently important to justify it. This distribution, will, do doubt, extend further as the demand for services grows.

OVERSEAS TRAINING OF BUREAU STAFF.

About the year 1922 the then Director appreciated the necessity for further highly trained personnel, particularly a sugar cane pathologist. This position was advertised in Australia and abroad but no suitable applicant was forthcoming. It was then realised that the sugar industry would have to train its own men and at that time the late Chief Justice McCawley, who was a Senator of the University, suggested to the Minister for Agriculture that three 3-year scholarships be awarded, the holders to undertake to work in the Queensland sugar industry for at least three years on completion of their courses. The Director, to whom this recommendation was referred, quickly recognised the advantage that would accrue to the Bureau and he therefore recommended that three selected students who had graduated in various branches of science should proceed abroad to study soils and agriculture, plant pathology and mill technology respectively. The recommendation was approved by Cabinet and in 1924 H. W. Kerr, A. F. Bell and N. Bennett were selected for these studies. On their return to this State, in 1928, all three joined the Bureau of Sugar Experiment Stations and in the following year took charge of the Divisions of Soils and Agriculture, Pathology and Sugar Mill Technology which had been formed as the result of a reorganisation.

ADVANCES IN AGRICULTURAL RESEARCH.

It was not long before the recommendation to train men overseas was vindicated and the scientific work of the Bureau of Sugar Experiment Stations proceeded at a new and increased tempo. New staff was recruited and trained and full use was made of the relatively new methods of field experimental technique. Field fertility trials—firstly of a qualitative and later of a quantitative type—were laid down in all cane-growing districts and these were made complementary to a programme of soil survey and soil analysis. For the first time a true picture of the plant food deficiencies and responses of the various soil types began to be obtained and, as the years passed, fertilizer recommendations could be made with surety and with a high degree of precision.

Such associated subjects as green manuring, trash conservation, molasses as a soil amendment, soil acidity and liming, cultivation methods, irrigation, &c., were the subjects of extensive experimentation, and growers in the industry showed an increasing interest in the practical application of the results of this work. Considerable increase took place in the field staff personnel who were in the main responsible for the planting and harvesting of the trials and for the extension service.

SPEEDY RESULTS FROM PATHOLOGY RESEARCH.

Similar spectacular advances were soon apparent in the pathology division. At the time of formation of this division Queensland was in the unenviable position of having present a greater number of major sugar-cane diseases than any other cane-growing country. Gumming, downy mildew, leaf scald, Fiji, chlorotic streak, mosaic, red rot and red stripe were all taking their toll and there was a dearth of resistant varieties. A vigorous policy of varietal introduction from overseas countries was instituted and this was combined with the division of the State into quarantine areas, a system of disease-resistance trials, a progressive cane breeding programme and the establishment of control measures in diseased crops. The combination of prevention, eradication, cane breeding and legislative control paid rapid dividends. A miscellany of useless or below average varieties ceased to be planted and an approved variety list was issued for each mill area. Cane plant selection with simultaneous destruction of badly diseased fields resulted in healthier and better yielding crops. The introduction of varieties resistant to the particular disease and the establishment, under Sugar Experiment Stations Acts of Disease Control Boards which regularly rogued all stools found affected with certain diseases, all contributed to the final result. To-day, gumming disease no longer exists in the State, downy mildew is apparently under complete control and Fiji disease has been restricted to a relatively small area. Cane breeding has given a supply of varieties which are mostly resistant to mosaic and the incidence of other diseases is decreasing annually.

Much of the credit for this improved state of affairs can be given to the excellent legislative measures which have been incorporated within *"The Sugar Experiment Stations Acts,* 1900 *to* 1948." The 1938 Amending Act introduced such major changes as the approved variety list, the various measures relating to destruction of diseased crops, and the Cane Pest and Disease Control Boards. These Boards have, through their supervisors and inspectors, done invaluable work in reducing the incidence of disease and, in some cases, in completely eliminating it.

The first Advisory Board—
Front: W. F. SEYMOUR HOWE, Hon. F. W. BULCOCK, J. SMITH.
Rear: Dr. H. W. KERR, B. COURTICE.
Absent: W. D. DAVIES.

THE SUGAR EXPERIMENT STATIONS ADVISORY BOARD.

During 1933 industry interest in the work of the Bureau attained such a high pitch that, at the invitation of the then Minister for Agriculture a Sugar Experiment Stations Advisory Board was formed. Two representatives from the Queensland Cane Growers' Council, one from the Australian Sugar Producers' Association, and one from the Queensland Society of Sugar Cane Technologists, together with the Director of Sugar Experiment Stations and the Minister for Agriculture and Stock (as Chairman) constituted the Board. The Minister and the Director act as permanent members of the Board but the industry representatives are elected each three years. All matters of policy affecting the workings of the Bureau are discussed at meetings which are convened every three or four months and the industry nominees are enabled to advise on any subjects and to report back to their organisations. All sections of the industry are thus able to assist in the framing and implementation of Bureau policy and to ensure that the Sugar Fund is expended wisely and to the maximum advantage of both millers and growers.

HOW THE BUREAU IS FINANCED.

The Act of 1900 provided for the establishment at the Treasury of the Sugar Fund out of which are paid all expenses incurred by the Governor in Council, the Minister or the Director in the execution of the Act. Provision is made for the levying of an assessment for each year on every ton of sugar cane received at a sugar works, the assessment being paid and borne by the owner of the sugar works and the grower of the cane respectively in equal proportions. These contributions were endowed by

MEMBERS OF THE SUGAR EXPERI

The Hon. H. H. COLLINS, Minister for Agriculture and Stock (Chairman).

Mr. N. J. KING, Director of Sugar Experiment Stations.

Mr. L. G. SCOTNEY, Canegrowers' Representative.

RATES OF ASSESSMENT LEVIED ANNUALLY SINCE 1900.

Year.	Rate Per Ton of Sugar Cane.
1901–1905	One penny
1905–1909	Nil
1909–1917	One half-penny
1917–1918	Three farthings
1918–1920	One half-penny
1920–1923	One penny
1923–1926	One half-penny
1926–1927	One farthing
1927–1928	One half-penny
1928–1929	Three farthings
1929–1930	One penny
1930–1935	One half-penny
1935–1937	One penny
1937–1942	Three farthings
1942–1945	One half-penny
1945–1946	Three farthings
1946–1948	One penny
1948–1950	Two pence

MENT STATIONS ADVISORY BOARD.

Mr. J. W. INVERARITY, Millowners' Representative.

Mr. J. C. COLLIER, Millowners' Representative.

the Treasury £ for £, but the Act of 1934 provided that the total endowment should not exceed £7,000 in any one year.

The work of the Bureau of Sugar Experiment Stations has eminently justified the intention of the prime movers who were responsible for its creation, and it can be confidently held that, during the past half century, it has been run economically, and the results of its work have benefited the industry in no small degree. The rates of assessment have been low and have been fixed from year to year in accordance with the programme of work and having due regard to the limitations of the Act.

The Bureau of Sugar Experiment Stations in Queensland is an integral part of the Department of Agriculture and Stock and as such is a Government instrumentality, although financed in

Mr. W. POUSTIE, Canegrowers' Representative.

the main by industry monies. The Government has been fully appreciative of the benefits likely to accrue to the industry as a result of overseas experience, and during the past 26 years several members of the staff have visited other sugar-cane producing countries and passed on the knowledge thus gained to the local growing and milling interests. No less than ten members of the Bureau staff have had the benefits of such overseas experience and the selection of the personnel was such that each of the divisions of Soils and Agriculture, Pathology, Entomology, Mill Technology, and Cane Breeding were adequately represented. Advantage has also been taken of overseas experience in another way since five members of the staff were at different times recruited from other countries.

PUBLICATIONS.

Under the Acts the Director is required to submit to Parliament in each year a report covering the activities of the Bureau. Such reports, to be readable, must of necessity be limited as to detail and it is essential that separate publications be issued on various subjects for the dissemination of such knowledge as may be of value to the different sections of the industry.

During the earlier years of the Bureau a series of Farm Bulletins was the principal avenue used for relaying to canegrowers advice on cultivation problems. Technical publications of the same period concentrated principally on entomological investigations. In the twenties several pathology Bulletins were issued to advise growers on means of identification and methods of control of cane diseases.

It was in the thirties, however, that publications were placed on a more regular basis. The increasing scale of field investigational work made essential some means of rapid dissemination of advice on all phases of agricultural work, and accordingly the Canegrowers' Quarterly Bulletin was started. This publication has been issued since 1933, and contains, in readily understandable form, all information gleaned from the Bureau's field and laboratory work. A short time later the need was felt for a research publication to deal with more technical phases of the organization's work, and a start was made with the series of Technical Communications which have been issued since that time. These cover the work of the Divisions of Mill Technology, Entomology, Pathology and Agriculture as well as laboratory and cane breeding studies. The Mill Technology Division has also issued in recent years a periodical News Letter to keep mill executives informed on items of interest.

PERSONNEL OF THE BUREAU STAFF SINCE 1900.

Name.	Division.	Period of Service.
Abbott, R. A.	Agriculture	1941–1949
*Adkins, B. G.	Mill Technology	1947–
Anderssen, A. E.	Chemistry	1902–1908
*Anderson, J.	Agriculture	1950–
†Barke, E. J.	Agriculture and Cane Breeding	1920–
Barrett, J. H.	Agriculture	1949
Barton, L. C. Miss	Clerical	1946–1950
*Bates, G.	Entomology and Agriculture	1923–
Behne, E. R.	Mill Technology and Administration	1930–1948
Bell, A. F.	Pathology and Administration	1928–1947
Bennett, N.	Mill Technology	1928–1932
*Bieske, G. C.	Chemistry	1949–
Blackford, F. W.	Agriculture	1934
*Brain, L. R.	Mill Technology	1947–
*Burge, J.	Chemistry	1948–
Burn, H. G.	Agriculture	1913–1915
Burns, A. N.	Entomology	1925–1930
*Buzacott, J. H.	Entomology and Cane Breeding	1926–
*Carroll, K. M. Miss	Clerical	1949–
Cassidy, N. G.	Chemistry	1930–1945
*Challenor, M. L. Miss	Clerical	1948–
Cheetham, P. J.	Agriculture	1949–1950
Christensen, J.	Chemistry	1910–1911
*Christie, G. A.	Agriculture	1933–
*Claire, A. G.	Mill Technology	1950–
*Clayton, J. L.	Mill Technology	1938–
Cottrell–Dormer, W.	Entomology and Pathology	1922–1934
Cullen, B. J. Miss	Clerical	1942–1947
Davis, M. B.	Chemistry	1910–1914
Denham, J. B. Miss	Clerical	1946–1949
Dodd, A. P.	Entomology	1912–1921
*Dodgson, C. Miss	Clerical	1947–
*Doolan, A. D.	Mill Technology	1949–
*Doolan, F. M. Miss	Clerical	1950–
Easterby, H. T.	Administration	1900–1910 1912–1932
*Egan, B. G.	Pathology	1947–
Eigenhuis, J.	Mill Technology	1935–1938
Elliott, J. T.	Agriculture	1940–1950
Ferguson Wood, E. J.	Pathology	1925–1932
Foran, J. L.	Chemistry and Agriculture	1911–1919
Foster, —	Chemistry	1905–1908
Gibbons, W. D.	Pathology	1944–1946
Gibson, A. J.	Chemistry and Administration	1902–1904 1910–1912
Gibson, A. P.	Agriculture	1915–1918 1925–1937
Girault, A. A.	Entomology	1911–1914 1918–1919
*Graff, N. G.	Agriculture	1949–
Harvey, H. T.	Agriculture	1912–1915
Henry, A. R.	Clerical	1902–1915
Holden, P. Miss	Clerical	1946–1948
*Home, L. C.	Chemistry	1938–
*Hughes, C. G.	Pathology and Cane Breeding	1934–
*Humphry, E. V.	Agriculture	1940–
Illingworth, J. F.	Entomology	1917–1921
Jarvis, E.	Entomology	1914–1935

* Present Members of Staff.

† Seconded to Commonwealth Agricultural Re-establishment Organisation.

PERSONNEL OF THE BUREAU STAFF SINCE 1900—continued.

Name.	Division.	Period of Service.
Jenkins, G. H.	Mill Technology	1937–1941
Jones, J. F. Miss	Clerical	1947–1948
Kelly, N. L.	Pathology	1925–1933
Kelly, S. J.	Chemistry	1924–1930
Keogh, F.	Chemistry and Agriculture	1919–1935
Kerr, H. W.	Agriculture and Administration	1928–1943
*King, N. J.	Agriculture and Administration	1933–
*Knust, H. G.	Agriculture	1937–
*Leddy, S. C.	Clerical	1947–
Leece, C. W.	Clerical and Pathology	1930–1942
*Leverington, K. C.	Chemistry	1944–
*Lindsay, F.	Agriculture	1948–
Linklater, D. W.	Clerical	1936–1950
Littlemore, S. M.	Chemistry	1904–1907
*McBryde, D. L.	Agriculture and Mill Technology	1933–
McCready, L. C.	Chemistry and Agriculture	1903–1917
McDougall, W. A.	Entomology	1928–1949
McWalters, P. H.	Agriculture	1919–1927
*Matthews, A. A.	Agriculture	1950–
Maxwell, W.	Administration	1900–1909
*Mungomery, R. W.	Entomology	1925–
Murray, J. C.	Agriculture	1918–1932
*Myatt, O. W. D.	Agriculture	1946–
*Nicklin, J. H.	Mill Technology	1945–
O'Brien, C. H.	Chemistry	1901–1903
O'Gorman, D.	Clerical	1900–1902
Osborn, E. H.	Agriculture	1921–1937
Patch, R. B.	Clerical	1940–1946
Patten, G. R.	Chemistry	1902–1915
Peel, A. C.	Clerical	1934–1936
*Pembroke, E. A.	Agriculture	1941–
Praeger, A. H.	Mill Technology	1938–1944
Pringle, J.	Chemistry and Agriculture	1900–1937
Riley, R. V.	Clerical	1936–1947
*Searle, J. Miss	Clerical	1948–
Scriven, E. G.	Administration	1910–1921
*Siemon, M. D. Miss	Clerical	1950–
*Skinner, J. C.	Cane Breeding	1950–
*Skinner, S. O.	Agriculture	1936–
Sloan, W. J. S.	Agriculture	1945–1948
Smith, N.	Mill Technology	1935–1937
*Smith, N. McD.	Agriculture	1939–
*Steindl, D. R. L.	Pathology	1935–
Stieglitz, C. R. von	Chemistry	1914–1945
*Stern, W.	Agriculture	1949–
*Story, C. G.	Agriculture	1935–
Taylor, F. H.	Entomology	1924–1925
Tesch, J. E.	Mill Technology	1945–1946
Thompson, F.	Chemistry	1900–1902
*Vallance, L. G.	Chemistry and Administration	1945–
*Venton, C. B.	Mill Technology	1946–
Williams, J. L. Miss	Clerical	1947–1950
*Wilson, G.	Pathology and Entomology	1926–1929, 1947–
Winders, J. R.	Clerical	1939–1945
Wylie, M. W. Miss	Clerical	1922–1938
*Yore, K.	Mill Technology	1950–
Young, G. E.	Mill Technology	1936

* Present Members of Staff.

The History of Sugar Soils Investigations and Agricultural Research.

By L. G. VALLANCE.

Mr. L. G. VALLANCE, Asst. Director.

It is not often that the opportunity arises to look back over half a century of work, and it is of interest to recall the statements made prior to its commencement by Dr. Walter Maxwell, who shortly after became the Bureau's first Director. Reporting on a survey of the sugar industry's needs in 1899, he said, "evidence has been furnished that no system of rational fertilisation has existed; that the cane lands in the main, have never received manures, and where manures have been used, it has not been by those methods which are known to command results. . . . . In the matter of cultivation, it is made to appear . . . that the modes of handling the land have been crude and superficial." Coming from an agriculturist who was familiar with the major overseas sugar growing areas, these statements paint rather a dismal picture of the agricultural efficiency of the Queensland industry at the close of last century. He made no secret of his opinion that this young industry could profitably adopt the methods of scientific research which were being successfully utilised in the much longer established industries in other parts of the world. This lesson was taken to heart and throughout the years Queensland's sugar industry has consistently refused to isolate itself. It has always shown a readiness to exchange ideas and information with overseas and to-day the efficiency of the production on the agricultural side compares very favourably with that of any other sugar growing area having due regard to natural advantages and limitations.

A first step to place cane land cultivation and management on a more scientific basis was the appointment of Maxwell as Director of the newly-formed Bureau of Sugar Experiment Stations. In addition to the investigation of all phases of the industry his intention was to advise "in all matters of the field, such as the selection of lands suitable, and leaving out of lands unsuitable for cane; the individual acts of cultivation; the resting and rotating of the soils with other crops; the introduction of other economic crops and sources of profit, and the instituting of new means for the restoring and maintaining of the producing power of lands. To examine soils in the field and take samples for analyses in the laboratories, and to advise manures according to the ascertained requirements of each soil and location." And so in the first annual report of the Bureau of Sugar Experiment Stations for the year 1901-1902 it is recorded that 573 soil samples had been taken and that some 2,413 analyses had been carried out on these and on samples of manure, irrigation waters, sugar canes, &c. Truly a spirited beginning.

The effect of overnight soaking of cane plants in water. Plants on right not soaked.

The analytical work proceeded apace and a large and increasing number of soil samples from all sugar growing districts was analysed during the next few years. The last annual report issued by Maxwell before he relinquished his position in 1909 stated that some 13,000 analyses of soils, waters, manures, sugars, &c., were carried out during the year 1908-1909 at the laboratory at Bundaberg.

THE COMMENCEMENT OF FIELD EXPERIMENTATION.

No time was wasted in laying out all manner of field trials. Cultivation experiments, trials to determine plant spacings, and investigations to determine the effect of lime and various fertilizers were set down with a great deal of enthusiasm and energy. Since only one experiment station, that at Mackay, was available, farmers were co-opted to establish and maintain experimental areas on their properties. In this way a series of "sub-stations" was soon in operation and in the annual report for the year 1902-1903 it is recorded that fourteen were already being conducted. These were located in Mossman, Mulgrave, Johnstone, Herbert River, Proserpine, Burdekin, Bundaberg, Isis, Pialba and Logan districts. Because of the lack of field staff and the not very rapid means of transport, it seems that the results of the trials were furnished in a report to the Director by the farmer concerned. This was apparently carried out very conscientiously at the beginning, since detailed statements of the cost of the various operations and the yields obtained were recorded.

INTERESTING RESULTS FROM SUB-STATIONS.

As might be expected the data obtained from these farm plots provided useful information regarding cultivation methods and farm management practices, since, irrespective of their investigational value, they represented the first systematic attempts to record the prevailing practices of representative growers. The layout of the trials varied a little throughout the various localities but in the main emphasis was laid on the comparison of subsoiling, deep ploughing, fertilizing and the use of lime, with the procedure described as the farmers' ordinary cultivation methods. This latter treatment was apparently rather elastic, and in the reports of some of the trials it was remarked that unfortunately the farmer had deviated somewhat from his usual methods. Presumably when confronted with advancing science the enthusiastic "sub-station" experimenter put his best foot foremost in no uncertain fashion.

However, thanks to the zeal and energy of all concerned, interesting results soon became available and in the fourth annual report (1903-1904) the following table of trial figures was published.

Trash conservation combined with irrigation on Bundaberg Sugar Experiment Station.

GENERAL RESULTS OF INTENSIVE AND ORDINARY CULTIVATION (1903–1904).

Locality of the Sub-Station.	Age of Crop.	Nature of Crop.	Intensive Cultivation (Plots of Sub-Stations).	Ordinary Cultivation (Farmers Areas).
			Tons.	Tons.
Mossman	13 Months ..	1 Ratoon ..	21·5	14·5
Mulgrave	ditto ..	Plant ..	21·0	11·0
Sundown	17 Months ..	ditto ..	25·5	20·8
Mundoo	ditto ..	ditto ..	25·4	12·1
Halifax	13 Months ..	1 Ratoon ..	25·9	17·0
Woongarra—				
Irrigated	ditto ..	Plant ..	30·0	19·0
Non-irrigated	ditto ..	ditto ..	16·0	9·0
Pialba	ditto ..	ditto ..	10·5	7·0
Beenleigh	ditto ..	ditto ..	25·3	24·9
North Isis (part irrigated) ..	ditto ..	1 Ratoon ..	38·2	12·0
Means	..	..	23·9	14·7

These were hailed as a resounding success for the new methods, and it was said that "if these farmers have done these things, then other farmers can do them if they will determine to follow the same advices and adopt the same methods . . ."

It was pointed out that since the average yield for the State for the past five years (13.2 tons per acre) was considerably below that of the experimental plots "there was no reason why the yield per acre of Queensland, which is about the lowest in the world, should not be doubled."

The necessity for the practical approach to the problem of increasing production was not lost sight of. In all these trials a close watch was kept on the economic angle and detailed costs of production were submitted for each treatment. As a typical example the following figures from the crop harvested in 1903 on the sub-station located on Mr. R. Reid's property, Mundoo, Johnstone R., are worth quoting. These are given in the table below and there seems little reason to doubt the recorded statement that Mr. Reid was perfectly satisfied with the results.

VALUE AND COST OF CROP PER ACRE.

Experiments.	Cane Per Acre.	Value Per Acre.	Cost Per Acre.	Profit Per Acre.
	Tons.	£ s. d.	£ s. d.	£ s. d.
Bureau Treatments Nos. 1 and 4 ..	26·0	19 10 0	14 1 6	5 8 6
Bureau Treatments Nos. 2 and 3 ..	24·8	18 18 0	12 14 6	6 3 6
Farmer's Ordinary Treatment ..	12·1	9 1 6	8 5 0	0 16 6

The detailed production costs make interesting reading but unfortunately space does not permit their reproduction. It might be mentioned however that in this year (1903) the cost of harvesting 26 tons of cane was £3 5s. By 1907 the ratoon crops of these sub-station trials were completed and no further trials on farmers' properties were set out until 1912.

The permanent Trash Trial at Bundaberg Sugar Experiment Station.

THE FIRST TRIALS ON THE EXPERIMENT STATION.

With the taking over of the old State Nursery at Mackay the Bureau acquired its first piece of land on which to conduct cultivation, fertiliser and green manurial trials. It is interesting to note the emphasis laid on the necessity for thorough soil preparation from the very inception of the investigational work. The first trial in this respect compared the results of growing cane on land which had been ploughed to eight inches with those on land which was ploughed to one foot and then subsoiled to a further six to eight inches. A difference of 20 tons per acre in favour of the deep cultivation provided the impetus for a spate of subsoiling trials which were persisted with for many years. It was claimed that the results of this trial showed that the cane produced by "deep, thorough and subsoil cultivation had a higher density, higher sucrose, lower glucose, higher purity and a very notably less content of fibre . . . ." In the face of these remarkable results it was possibly a matter of some disappointment that the early fertilizer trials gave only relatively small increases due to fertilizer. However these were the first attempts and there was much to be learnt about the correct usage of these materials, and some of the knowledge that to-day is taken as a matter of course, was yet to be gained. For instance, although some mixed fertilizers were used there was a bias towards the use of single elements to determine the respective values of nitrogen, phosphoric acid and potash. This laudable ambition was negatived by the application of one element at a time since undoubtedly the absence of the other two presented a limiting factor.

However, this was apparently soon realised, and by the end of 1909 the results of a number of fertilizer trials, some extending into the third ratoon crop, were available. It was recorded that applications of manure consisting of nitrate of soda, sulphate of ammonia, sulphate of potash and superphosphate had brought about increased yields of up to 17 tons of cane per acre in the various ratoon crops. Farmers were advised that they could obtain a fertilizer formula for their land by application to the Experiment Station. Three formulae were recommended. No. 1 was composed of sulphate of ammonia, superphosphate and sulphate of potash in the proportion

A farmer spreading rotary filter cake for fertilizer.

of 7.7 per cent. nitrogen, 7.0 per cent. water soluble phosphoric acid and 7.7 per cent. potash. No. 3 was somewhat similar but contained nitrate of soda in addition to sulphate of ammonia, and the formula appeared to be approximately 8 per cent. nitrogen, 6 per cent. phosphoric acid and 9 per cent. potash. It was considered that the increased nitrogen and potash content would be more beneficial to ratoon crops. For the Geraldton, Cairns and Mossman areas, No. 2 mixture was recommended containing 150 lb. sulphate of ammonia, 300 lb. meatworks fertilizer and 150 lb. of potash. It was not explained why the meatworks material was considered to give better results in these particular districts.

The lime requirement of the various soils also received considerable attention, and amongst the early experiments several lime trials were set out. The beneficial results obtained encouraged the Bureau to recommend strongly that one ton of lime be applied to cane soils every four or five years.

It is interesting to note also that, from the very outset the value of green manuring was recognised and at the first plantings on the station the productivity of various types was tested. Amongst these were soya bean, lupins, cowpea, tares, velvet beans, rape, and Black Mauritius bean. The use of some of these is standard practice throughout the industry to-day.

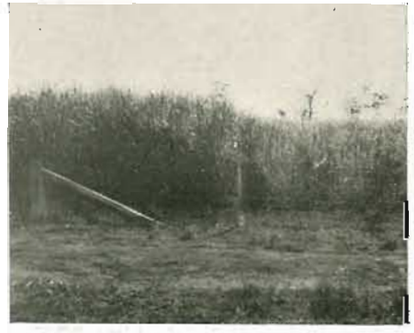
OTHER EARLY TRIALS.

Apparently in these early days the stripping of trash from the cane during the growth was a fairly general farm practice. This was looked upon with some suspicion by the Bureau, particularly in view of investigations carried out overseas about that time. Accordingly therefore in 1910 it was decided to put down a trial on Mackay Station to compare early and late trashing versus no trashing. However, in the following year it was announced that the trial was not proceeded with because farmers had, by now, virtually abandoned the practice. Whether this latter move was due to the Bureau's doubts regarding the value of stripping or the farmer's own experiences is not mentioned. However, the land which had been reserved for the trial was planted to cane in order to conduct a manurial trial. This experiment was somewhat different from the previous trials in that the block of land was divided into two parts. On each portion a similar fertilizer trial containing five treatments was put down. In the eyes of the experimenters the results obtained were remarkable. They were faced with the fact the two similarly treated halves of the trial gave entirely different results. The experiment was carried on to the second ratoon crop, as a result of which the figures apparently became even more inconsistent and bewildering. It was

Molasses application to young ratoons. The warm liquid is run directly on to the cane.

concluded that the "interpretation of such experiments required the greatest care."

Whether it occurred by accident or design, this was apparently the first real trial on which the results obtained were not based upon the yields of single plot experiments. However, the day of statistical analyses of agricultural experiments had not yet dawned in Queensland, and with an honest admission: "that many factors, some known and some unknown, play their part . . . .", the Experiment Station turned its attention to other matters. One of these was an experiment to determine whether cane setts from arrowed cane were as good as setts from non-arrowed cane. This was set out in single plots on what was termed to be an "absolutely" uniform piece of land.



Part of a fertilizer trial at Bundaberg. Non-fertilized plot on right.

Soil erosion on red soil hillside at Childers.

It so happened that at the harvest of the plant and first ratoon crops the cane grown from the setts taken from arrowed cane produced the greatest yield.

TRIAL PLOTS ON FARMERS' PROPERTIES AGAIN ESTABLISHED.

As previously mentioned, the idea of substations on farms throughout the various districts was discontinued in 1907. However, in 1912 it was recorded that some fourteen experimental plots were established in the northern and southern sugar districts. These had three objectives in view—

(*a*) To test green manuring, subsoiling, use of lime and fertilizers upon varying soils.

(*b*) To test approved varieties of cane in different localities.

One of the contour drains in a soil erosion control experiment at Childers. This demonstration was put down by the Bureau.

(*c*) To provide for the distribution of the approved varieties in such districts, thus avoiding the cost of carriage and time lost between the time of cutting at Mackay and the receipt of canes by farmers in far away districts.

This policy was pursued vigorously for a few years, and a considerable amount of information was obtained. Actually the plots functioned as very useful demonstrational areas and were visited as frequently as possible by the field officers. However, with the coming of World War I. and the subsequent loss of field assistants, considerable difficulty was experienced in maintaining the fertility and cultivation experiments attached to these plots. In 1916, therefore, it was decided to abandon this part of the farm trial programme and retain only the varietal testing and distribution plots. These latter were of considerable interest and usefulness to growers in the various centres and were the forerunners of the comprehensive series of varietal trials and propagation plots which are maintained in practically all sugar areas at the present time. Moreover, since the Bureau now had its recently acquired experimental station at Bundaberg in addition to the Mackay Station, it was felt that the intricacies of quantitative fertilizer and cultivation trials could be more efficiently catered for if set out on these properties under the full control of Bureau staff.

GRADUAL IMPROVEMENT IN DESIGN OF FIELD TRIALS.

As has been already mentioned, all trials in the early years were of a very simple form, in which a single plot only, of each treatment, was used. Under these circumstances what appeared to be a clear-cut result was nearly always obtained. The treatment given to the plot which produced the highest yields was considered to be the best. Although the possibility of the existence of soil heterogeneity and fertility gradients was undoubtedly recognised, the experimental staff unfortunately had no effective counter, except to insist that an absolutely

View of soil erosion prevention trial just after planting.

uniform piece of land be selected as the site of the experiment. However, the records do not indicate how the conclusion that the land was uniform was arrived at. Of course, in the first stages, when trials comparing the use of fertilizer with no fertilizer on soils which had been cultivated for many years without the addition of N. P. or K. were carried out, the results of the fertilizer applications were so marked that there was actually little necessity for replicated experiments. However as time went on and attempts were made to define soil requirements more closely, it soon became evident that something was wrong with investigational methods. The fertilizer trial already referred to on Mackay Station which was apparently unwittingly put down in duplicate was the first which indicated that there was room for improvement in experimental technique.

It is of interest to note that in 1914 three trials were set out on Bundaberg Station to test the value of liming and subsoiling, with and without manure. Each trial consisted of two treatments and was put down in duplicate. It must have been a matter of some satisfaction that, when the results were obtained, it was possible to report that the duplicate plots agreed exactly. The Bureau felt reasonably secure in making the recommendation that subsoiling and liming was not a payable proposition on the red volcanic Woongarra soils. However those concerned were quick to appreciate the vagaries of climatic conditions, and the proviso was added that it would be advisable to again test these treatments when the soils were less influenced by dry weather. Incidentally, these trials have been repeated in many different forms over the years and no response to liming or subsoiling has ever been achieved on Bundaberg Station.

After this, although the various treatments frequently occurred as single plots it became a fairly general practice to put down the check or "no treatment" plots in duplicate. In 1919, the first manurial trial which was planted out on the new station at South Johnstone consisted of seven treatments in single plots. These were laid down side by side with a check plot separating each treatment. The results obtained from the seven check plots provided food for thought. Not only were they all different but the yields increased as the sites receded from the side of the hill (Basilisk) at the foot of which the experimental area occurred. Here, then, was a typical fertility gradient, and it is pleasing to note that its presence was immediately recognised. In order to assess the results of each fertilizer treatment it was decided to compare the yields with the mean of the two check plots which were located on either side. This was done until the experiment concluded with the harvesting of the third ratoon crop in 1923. By this time however it was a frequent occurrence for

Heavy soil erosion on a newly planted field. Note cane plants on surface.

trials to be laid down in triplicate, although there was as yet no attempt at randomisation or to use the standard methods of technique which were beginning to be used in other parts of the world. However, it must be remembered that it was not until Fisher had established the Statistical Laboratory at Rothamsted in 1919 that the principles of randomisation were propounded and the analysis of variance devised.

Nevertheless, the Bureau was making determined efforts to ensure the validity of its trial results, and in the Annual Report for 1926 attention was drawn to the conclusion of experiments for testing the uniformity of the soil. This referred to work on Bundaberg Station, where the yields from four unfertilised plots were compared with those of four plots which had been uniformly fertilized. The Director in summing up the results stated that "the disparity in results between contiguous plots shows the necessity for carrying out experiments in duplicate."

It was not long after this that the Bureau completely reorganised its experimental methods. The return from overseas of the graduate scholarship holder in Soils (Dr. Kerr)) provided the necessary impetus. The newly formed Division of Soils and Agriculture under his direction in 1929 immediately planned a scheme of farm experimentation designed to test the fertilizer requirements of the widely varying soil types that occurred throughout the sugar areas. The experimental plan was generally a 5 x 5 Latin Square together with some randomised block trials in which liming was combined with fertiliser tests. In this year it is recorded that 46 farms with soil types of major importance were selected and fertility trials set out in order to obtain "information regarding response to plant food constituents, singly and in combination." The current trials on the experiment station were allowed to run their course, but as these reached finality they were replaced by others

Serious erosion subsequent to germination on red soil at Childers.

designed on sounder field experimentation principles. Varietal trials also were laid down as Latin Squares or fully randomised blocks and this made better provision for the final testing of new canes against the older varieties, as far as yields and sugar per acre were concerned.

The large number of fertilizer trials was built up around a uniform type of trial as far as possible. The treatments were C (check), N., N.P., N.K. and N.P.K. Field assistants rapidly became familiar with this standarised type of trial, and this was a factor which was not unimportant insofar as the laying out of a very large number was concerned. However, about 1930 this was replaced by the factorial layout (3 x 3 x 3) in which three levels of N.P. and K. were used. Such trials have been retained until the present day and proved extremely useful for the routine testing of fertilizer requirements, particularly in conjunction with soil surveys. Today the Department of Agriculture and Stock maintains a very efficient Biometrics Section, the services of which are freely available to the Bureau. The designs of all quantitative trials are submitted to this section before the experiment is laid down, and when the results are to hand the complete trial data is again passed to the biometrician for analysis.

SOME HIGHLIGHTS OF THE MANY CULTIVATION AND FERTILIZER TRIALS.

It is of course impossible to enumerate here the many and varied trials that have been carried out over the fifty years under review. For many years and indeed up to quite recent times the value of subsoiling was investigated in trials of various forms. In general the results have indicated that deep loosening of the soil below normal plough depth is worthwhile, particularly on the heavier alluvials and on soils with clayey subsoils. No beneficial results were ever obtained on red volcanic loams, and after a series of very useful trials on Bundaberg Station, the statement was made in 1938 that "it must be concluded that the value of cultivation operations on red volcanic soils—beyond that of weed control—is nil."

A Queensland cutter-planter.

Methods of ratooning have also received considerable attention. As early as 1910 at Mackay a trial was laid down to decide which was the best practice for ratoon cane. The treatments were briefly as follows:—

(*a*) Volunteering with trash left on ground.

(*b*) Burying trash in interspace.

(*c*) Relieving, trash placed in alternate interrows, cleared rows ploughed and subsoiled.

(*d*) Trash burnt, interrow ploughed and subsoiled.

However dry weather interfered and the experiment was repeated in 1912, the second ratoon crop of the trial being harvested in 1915. In the first ratoon crop the best results were obtained from the plot in which the trash had been burnt and the interspace subsoiled. However the results were almost completely reversed in the second ratoons in which the highest yields of sugar and cane per acre were obtained from the volunteered plots. The experimenters were possibly somewhat nonplussed and ratooning experiments remained *tabu* until 1919, when a somewhat similar trial was laid down on South Johnstone Station. This was considered to be much more success-

ful in that both first and second ratoon crops consistently indicated the benefits of burning trash and deep cultivating between each row. Amongst other ratooning trials mention is made of one carried out at Mackay in 1930. In this case each treatment was replicated five times. The treatments were—

(*a*) Three furrows ploughed 6 in. deep and worked level with harrows.

(*b*) Ratooned with spring toothed harrows.

The results show that no differences due to treatment occurred.

In assessing the value of all these cultivation and ratooning trials it is clear that considerable difficulty was encountered in obtaining results to prove that any particular method was superior to all others. It is equally clear that the Bureau fully recognised that this was due to the influence of prevailing weather conditions and varietal and soil characteristics. Undoubtedly a great deal was learnt that was of tremendous importance to the advisory and extension work, and it was repeatedly stressed that good farm management went hand in hand with an appreciation of the particular conditions under which the crop was being grown. On reading through the results of the experimental work one cannot help being impressed with the fact that the Bureau staff throughout the years possessed the fundamental outlook of the practical farmer, around which they built up added knowledge by means of the scientific tools which they used to the best possible advantage.

Little need be said of the many plant and row spacing trials, the results of which are reflected in the methods in general use at the present day. In these trials due cognisance was taken of varietal requirements and district conditions as was also done with trials to compare early and late planting.

Undoubtedly the most successful trials, exclusive of those associated with the cane breeding programme, were those whose purpose was to indicate the correct usage of fertilizers. The earliest experiments revealed the outstanding need for replenishing the plant food content of practically all soils of the sugar areas, whilst the latter trials aimed at showing the most efficient and economical way of doing so. The marked refinement in technique about 1929 by the adoption of the statistical method has already been mentioned. From this time onward there is no gainsaying the fact that the fertilizing methods used in the industry have been put on a sound and very satisfactory basis.

Punting cane on the Maroochy River.

TRIALS WITH MOLASSES AND MILL MUDS.

Over the years a number of trials designed to compare the fertilizer value of mill by-products such as molasses and mill muds have been set out. Replicated experiments with molasses ran for some time on South Johnstone, Mackay and Bundaberg Experiment Stations. In all three cases the value of molasses as a direct supplier of plant foods was demonstrated. Some interesting differences were observed at the various stations, for instance on the red volcanic soils at Bundaberg there was little difference in the increased yields due to molasses as compared with those brought about by the application of equivalent amounts of N.P. and K. as fertilizer. Apparently, on this highly ferruginous soil which has maintained its excellent physical condition in spite of continuous cultivation, molasses was beneficial only because of its plant nutrient content. At South Johnstone, the consistently better performance of molasses in comparison with fertilizer led to a remark in the 1934 Annual Report stressing "the value of molasses as a most suitable material for rejuvenating old lands." During recent years a series of laboratory studies have indicated the value of molasses in increasing the percentage of water stable aggregates of many sugar soils.

The results of trials to provide evidence as to the value of mill muds have been less convincing. It has not yet been possible to show that this material has any value beyond its actual plant nutrient content. In addition, because of its rather low and unbalanced proportion of N.P. and K. it would appear that any yield increases due to its application can often be more efficiently and economically reproduced by suitable mixed fertilizers.

Bulldozer at work clearing land for cane growing.

SOME INTERESTING "PERMANENT" TRIALS.

In 1934 a trial to investigate the value of conserving trash was commenced on the red volcanic soil at Bundaberg Station. On the trash plots all cane is cut green, the trash and tops are conserved and eventually ploughed in after the second ratoon crop. On the no trash plots all plant residues are burnt. This trial has been maintained continuously and is now in its fifth cycle, each cycle consisting normally of a plant and two ratoon crops. It is interesting to note that to date no increase in crop yields have been obtained due to the conservation of the trash. There is no apparent difference in the soil due to treatment and repeated analyses have failed to detect any increase in the carbon content of the soils of the plots receiving trash. It may be pointed out that the physical condition of this red basaltic loam is excellent and no deterioration has occurred due to continuous cultivation.

On the same station two other long term trials are established. One was designed to investigate the effect of long (18 months) and short (6 months) fallow periods in conjunction with green manuring while the other was set out to further examine the effect of trash conservation, with and without green manuring. These trials have been carried on since 1938, and no difference due to the various treatments have yet been indicated. It would appear that this stable-structured red soil maintains its natural good physical condition irrespective of management, a fact which was foreshadowed by the very early subsoiling and cultivation trials laid down soon after the opening of the Bundaberg Station.

A cane farm newly cleared by bulldozer.

A WIDE OUTLOOK.

Enough has been said in the foregoing pages to exemplify the wide outlook adopted by the Bureau since its inception, as far as all aspects of farm management practices are concerned.

Poona Pea Crop, Bundaberg Sugar Experiment Station.

However, there are many facets of the half-century of experimental work to which only passing reference can be made. For instance, it is interesting to note that the first trials for the control of weeds by the use of various chemicals (mainly arsenic) were laid down as early as 1915. Although the results were encouraging the costs were prohibitive. This type of work lapsed until very recent years, and at the present time an intensive series of trials with hormone weed killers and oil emulsions is in progress.

When cane planting equipment began to replace hand planting, a trial was established to compare the results obtained with this new method and those given by the old. This was carried through into the second ratoon crop just in case ratooning was also unfavourably affected. Specially imported stubble shavers and mole drainers were also tried out under varying conditions. At the beginning of the century the Bureau showed a keen interest in mechanical harvesters, and this has been maintained throughout the years. Literally dozens of new types of Australian inventions have received attention, and there are very few overseas machines which Bureau officers have not inspected and reported upon. In recent years the Director is represented on a Committee set up by the industry and the Commonwealth Government for the express purpose of encouraging and assisting the development of harvesting and loading machinery. The working of this Committee has been particularly useful, since its inauguration coincided with the development of several successful harvesters which are at present in commercial use.

The matter of soil erosion in sugar areas has been a vexed one for many years. At first sight it may seem strange that more trouble is encountered in this respect in the southern areas of lower rainfall than in the wet belt of the far North. However, experience has shown that to cultivate topographically unsuitable land in the 100-180 inch rainfall districts is suicidal. Erosion control is impracticable and uneconomic and therefore sugar growing has naturally restricted itself to flat areas, whereas in the south, cane has encroached on hillside slopes which would not have been brought into cultivation under the much more obvious erosion potential existing in North Queensland.

Over the years the advisory and extension services of the Bureau have stressed the desirability of top soil conservation and much specific advice has been given to growers in this report. It is only recently however that more active steps have been taken to combat this problem.

A crop of Crotalaria goreensis being ploughed into cane land.

Velvet beans on Bundaberg Sugar Experiment Station. This crop contains nearly 20 tons per acre of green material.

In 1945 a typical hill side slope in the Isis district was selected, and control measures in the form of graded banks and ditches of the Nichols type were set out. Very useful information was obtained from this exploratory trial, and further work is planned in co-operation with the lately instituted Soil Conservation Section of the Department of Agriculture and Stock.

WORK OF THE LABORATORIES.

From the commencement of the laboratory work in 1900, considerable emphasis was placed on the value of soil analyses and the laboratories at Bundaberg and Mackay were equipped to carry out quantitative chemical work. A considerable amount of painstaking work was performed by the analysts stationed at these centres, the object "being to demonstrate in the first place the plant food immediately available, the acid soluble plant food which by process of weathering, etc., is gradually becoming available, and finally the analyses of the insoluble residue of the soils demonstrating the store of plant food locked up in insoluble silicates. which may in course of time, gradually be added to the acid soluble plant foods." This was indeed a most comprehensive conception of assessment of the fertility of the various soils.

Initially one per cent. aspartic acid was used as the extractant for available plant foods. These values were at times compared with those obtained by using acetic, citric and hydrochloric acids of the same concentration. In 1909 it was stated that Maxwell's aspartic acid method was considered to be the most useful, and the one which approximates most closely in showing the amount of the necessary elements available for cane

A green manure crop being ploughed in prior to planting.

Soil.	Total Elements in Soil (Per Cent.).				Available Elements in Soil (Per Cent.).		
	Lime.	Potash.	Phosphoric Acid.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Good ..	·916	·344	·188	·103	·1650	·0344	·0078
Bad ..	·210	·250	·160	·173	·0087	·0049	·0003
Wallum ..	·063	·061	·072	·042	·0097	·0036	·0012

(Wallum soils are "typically poor sandy waste lands.")

crops. Unfortunately no details of the premises upon which this assumption was based appear to be available. In this respect a table published by Patten summarising the results of a large number of analyses is of interest. This is reproduced above.

However, by about 1914 the citric acid method of determining available plant food seems to have replaced the aspartic acid analysis. For many years a large number of analytical figures were recorded which were estimated by the so-called "agricultural method." This was done by using hydrochloric acid. The concentration was not stated but was most probably constant boiling point acid.

In 1911 the analytical laboratory at Bundaberg was closed. The staff was transferred to Brisbane and the work was carried out in the laboratories of the Agricultural Chemists Branch of the Department of Agriculture and Stock under the direct supervision of the Agricultural Chemist (J. C. Brunnich). The analytical work for Mackay and north of that area was done at the Mackay Station, where L. C. McCready was Chemist in Charge.

In 1915 facilities for cane analyses were provided at the newly opened experiment station at Bundaberg. A year later it was recorded that the number of canes tested for farmers had increased because of the Central Cane Prices Board having fixed a price for cane on an analysis basis. Growers availed themselves freely of this service for many years. During the crushing seasons 1920-22, Keogh (then Chemist in Charge, Mackay)) carried out an intensive series of tests in order to compare the analyses of juice expressed by the small laboratory mill with the analyses of juice from the same canes made under normal crushing conditions at Racecourse Mill.

From 1914 to 1929 the bulk of the routine and investigational work on sugar soils was carried out by C. R. von Stieglitz in the laboratory of the Agricultural Chemist in Brisbane, where H. W. Kerr also carried out soil work prior to his departure as a scholarship holder for overseas training. The need for additional laboratory space was becoming a pressing need, and in 1930 the opportunity arose with the additions to the Agriculture and Stock building for the Bureau to acquire its own Brisbane laboratories. These were designed by the staff not only to fulfil immediate requirements but also with an eye to future expansion, and are in use at the present time.

With the return of Kerr, Bell and Bennett from overseas, new ideas coincided with the new facilities, and the Bureau was off to a fresh start. It is to the credit of the then Director, H. T. Easterby, that he encouraged and used to good advantage the new tools that he had at his disposal. The old methods of soil fertility assessment were suspended and an intensive programme of laboratory research in conjunction with field trials was instituted. The search began for chemical methods which would indicate the plant food requirement of the many and varied soil types of the sugar areas. The opportunity for the finally selected methods to prove themselves was provided by the large number of quantitative N.P.K. field trials which were being carried out each year.

Spray irrigation during a dry spring at Freshwater.

By 1934 it was possible to record that "studies of the relationship between field trials results and laboratory soil tests have been completed." These investigations were brought to a successful conclusion by Kerr and von Stieglitz, and fertilizer advisory recommendations per medium of soil analyses were placed on a satisfactory and workable basis. The methods are in constant use at the present day and have repeatedly proved their worth.

SOIL AND FERTILITY SURVEYS.

By 1930, the need was felt for the carrying out of soil survey work to provide a closer link between field investigations and laboratory studies. Accordingly, therefore, N. J. King, of the Agricultural Chemist's staff was seconded to carry out a reconaissance survey of the major soil types in the more important sugar districts. Subsequently this work was extended and more detailed surveys were made. The definition of the more important types provided extremely useful data and encouraged the training of the various field advisory officers in the recognition of soils in their districts. This latter provided the facilities for further work and to-day soil maps are available in the Bureau records for most of the sugar areas in so far as assigned land is concerned. Although a considerable amount of information regarding the characteristics of these soils has been obtained and is used as a working basis for many advisory and investigational purposes, up to the present very little of it has been published. However, the results of a survey of the soils of the

Irrigation of ratoon cane in the Ayr district.

Weedicide trial at Innisfail 20 weeks after spraying with 2,4-D.

Bundaberg district has been prepared for publication as a Technical Communication by King and is at present in press.

The first soil fertility survey was completed in 1940 and although the work was curtailed during World War II., some 24 surveys have been completed to date. This type of survey was made possible by the development of satisfactory laboratory methods for the determination of phosphate, potash and lime requirement. Briefly the method consists of sampling certain blocks on each farm property in the district selected for survey. The soil samples are taken from plant cane blocks at or about the period of maturity of the crop, the most convenient time being just after harvesting. Wherever possible a factorial fertilizer trial is set out in the area concerned. The results have been found to be of considerable value in providing a systematic evaluation of the fertilizer requirements of the ara.

The soil and fertility survey work showed up to advantage during the fertilizer rationing imposed by shortages during the recent war years. Not only was it possible to allocate, with reasonable accuracy, the correct type of fertilizer for each particular farm but it was practicable to determine the amounts required to maintain efficient production.

OTHER IMPORTANT STUDIES.

With the opening of the new laboratories in 1930 in which von Stieglitz functioned as Analyst and Cassidy as Research Assistant, a large amount of chemical investigation was begun. Subsequently work was also carried out with the co-operation of L. C. Home of the Central Cane Prices Board, who was ultimately transferred to the Bureau staff in 1938. Reports on analytical methods in factory control and the use of the electrometric method for the determination of reducing sugars were published at intervals by von Stieglitz and Home. In addition investigations were carried out on the estimation of fibre and the associated necessary sampling technique, as well as work on the composition and clarifying properties of basic lead acetate.

Cassidy, working on the irrigation waters of coastal Queensland and their effects on various soils, adduced a considerable amount of useful information in

Boom spray on Farmall A.V. tractor. This is used for weed control with 2,4-D.

Field weighing of experimental plots.

Field weighing of experimental cane.

this respect, particularly with regard to exchangeable sodium and soil physical properties. These studies were subsequently published as Technical Communications and also as contributions to the Queensland Journal of Agricultural Science.

In the present lines of investigation emphasis is being placed upon the question of deterioration of sugar soils which have now been continuously cultivated to cane for a large number of years. An attempt is being made to determine the effect of various organic materials high in sugar, such as molasses and sorghum, on soil physical condition, and measurements made on the stability of structural aggregates have already indicated the beneficial effect of these materials. It is considered that the encouragement of the development of fungal mycelia is particularly important in this respect. The rate of decomposition of various materials such as legume residues, molasses and bagasse is also being studied.

Recent work has also shown that yield responses due to the application of lime are more closely linked with the calcium status of the soil rather than with pH values. This is possibly an indication that, whereas in the past, the correction of excessive soil acidity was an important function of lime application, continuous cropping and a high rate of leaching under tropical and sub-tropical rainfall conditions have now brought about a marked decrease in calcium availability as an essential plant food.

Acid soils react appreciably to liming. Lime was applied to the right hand side of this field prior to planting the green manure crop.

A Review of Sugar Cane Entomological Investigations.

By R. W. MUNGOMERY.

Mr. R. W. MUNGOMERY, O/C, Division of Entomology and Pathology.

Although 1950 marks the fiftieth anniversary of the establishment of the Bureau of Sugar Experiment Stations, entomological investigations were not incorporated in the original activities of the Bureau and it was not until 1911 that the Division of Entomology first came into being as an integral part of the Bureau's organisation. Consequently, although the present year does not represent the fiftieth year since the formation of the Division of Entomology, it does, however, constitute a convenient time in the Division's development to look back over the various lines of investigation that have engaged the attention of its entomologists from time to time, and to assess what has been accomplished in the interim.

That entomological and pathological investigations were not commenced concurrently with the establishment of the Bureau of Sugar Experiment Stations will be readily understood from the fact that when W. Maxwell was appointed first Director of the present organisation, he was so forcibly impressed with the extent to which soil deterioration had apparently occurred that he inclined strongly to the idea that the ravages of pests and diseases were closely linked with this decline in soil fertility. After examining the occurrence of white grubs and their attacks on cane under different conditions he was led to the following conclusion: "The examination leaves no doubt in the matter that the continuous ratooning, for successive years, and the dead condition and fouling of the soil, which, after one or two crops it involves, provides all the most favourable conditions for the propagation of the grub and furnishes another powerful reason for the introduction of a more rational and thorough system of cultivation." Later, while still on the subject of diseases and pests he was prompted to make the following remarks: "Quite certainly, any remedial steps taken for the rebuilding up of the producing power of the soil, and of the vitality of the cane, will also be actions begun for the resistance and removal of pests and diseases." Hence the emphasis during Maxwell's regime was on experimental work designed to restore soil fertility and thus indirectly to affect the different pests, rather than on any direct investigations seeking to elucidate their life histories and habits or to evolve control measures against those which were then known to be responsible for such huge annual losses. There can be no doubt that the status of the various cane pests was at that time fairly well understood, for it was on record that white grubs had been responsible for killing cane in the Mackay area as early as the 1870's, and in subsequent years damage had been recorded in the Ingham, Innisfail and Cairns districts. Other parts of the colony had also demanded attention against a number of pests which were causing trouble in localised areas, but there was probably nothing that caused more general anxiety amongst Queensland sugar growers than the annual threat from grubs—the immature forms of various cockchafer beetles. Right throughout the entire period that was later to be occupied by entomological investigations attention was focussed mainly on these pests.

In 1891 Keobele had visited Australia from Hawaii and reported that the moth borer pest differed from the destructive species found in the West Indies, Mauritius and elsewhere, whilst Olliff, Government entomologist of New South Wales, had surveyed sugar cane pests in that colony. Probably the first authoritative work on sugar cane entomology in Queensland was written and presented by Turner at an agricultural conference held in Mackay in 1892. Turner—an entomologist and canegrower in the Mackay district—detailed the identity of various pests which were responsible for losses in the industry, and he issued a note of warning regarding the possible introduction of others whose establishment in Queensland might be attended with more serious results. Later Tryon, Queensland Government entomologist, paid some attention to the greyback beetle and, *inter alia*, suggested soil fumigation and collection of grubs and beetles as likely to afford substantial relief. The latter measure was the only one that seemed to have been extensively adopted then, but it subsequently proved of little value.

This briefly summarises what was known up to that time regarding Queensland cane pests, and the extent of the control measures that had been put into operation when Maxwell took up duties in Queensland. In the few years prior to his arrival there had certainly been no improvement in the general position and he either had complete confidence that the rehabilitation of the depleted soils would prove an effective answer to the various pests, or else the problem was entirely ignored, for no further investigations on these pests were carried out during the next decade. During that

The first entomological laboratory at Nelson—now Gordonvale.

period there was still no abatement of the damage and leading members of the industry became determined that the position should not remain static. Their demands that further attention should be given to the grub pest crystallised the action which led to the appointment, in 1911, of A. A. Girault as first entomologist, and to the formation of the Division of Entomology. At the request of the Queensland Government Girault had been specially selected by the American Secretary for Agriculture to fill this position, and his arrival in Queensland was hailed with considerable satisfaction. Girault, however, realised that a considerable amount of basic investigation was necessary and accordingly he promised no spectacular results. Instead he undertook a vast amount of breeding work at Gordonvale in an effort to relate various grubs to the adult beetles, as well as to ascertain the duration of their life cycles, their habits and their relative economic importance. Soon after commencing this work he was joined by A. P. Dodd, and these two entomologists were conjointly responsible for the detailed technical data that later was published in their entomological bulletin, "The Cane Grubs of Australia."

Following the termination of Girault's engagement in 1914 he decided to return to America, and while steps were being taken to secure a successor, E. Jarvis, who had been associated with Tryon, in Brisbane, on entomological investigations, took over duties from Girault. Subsequently J. F. Illingworth was appointed

Dr. J. F. ILLINGWORTH, Entomologist, 1917-1921.

entomologist in June, 1917. Before coming to Australia Illingworth had been connected with the College of Hawaii as Professor of Entomology and he had also carried out special investigations for the Colonial Sugar Refining Company in Fiji. On assuming control of entomological investigations here he immediately expanded field experiments and later he collated much of the information that he and previous workers had gathered together. His comprehensive publication, "Australian Sugar Cane Beetles and their Allies" is one of the finest treatises on this subject, and his other works were of an equally high standard. Illingworth left in 1921 and Jarvis again took over control. Jarvis completed some of the investigations commenced by his predecessor and in addition carried out an extensive survey of the lesser known sugar cane pests. He possessed no mean ability as a delineator and one of his bulletins, "Notes on Insects Damaging Cane in Queensland," which was well illustrated by drawings and photographs, served as a means of identifying most insect pests associated with cane in Queensland. His monthly notes on cane pests were prominent for a number of years in several of the publications that circulated throughout the industry.

New acquisitions to the entomological staff in the next few years included W. Cottrell-Dormer and G. Bates. The former turned his attention to sugar cane pathology in 1924 and the latter to sugar cane agriculture in 1930.

The expansion in entomological activities in the later 1920's was in keeping with the general extension of scientific research throughout the Queensland sugar industry, and because of the awakened interest in entomological problems following upsurges of pest activity in parts of southern and central Queensland, R. W. Mungomery was appointed to the staff in 1925. After a short period at Meringa he subsequently took up duties at Bundaberg, where he studied southern cane pests—chiefly white grubs. Later he also collaborated with A. F. Bell in research on the transmission of various diseases by insect vectors, and these workers were eventually successful in proving that Fiji disease was spread by means of the sugar cane leafhopper.

In 1927 J. H. Buzacott joined the staff at Meringa and in the following year W. A. McDougall received a similar appointment. Subsequently, in 1931, McDougall took over duties at Mackay from A. N. Burns, who had commenced there some three years previously. Because the wireworm pest had been particularly troublesome there for a number of years McDougall devoted the greater part of his time to a study of this pest. His subsequent recommendations regarding efficient drainage went a long way towards lessening the losses caused by wireworms and in more recent years, when benzene hexachloride came on the market, he worked out a satisfactory technique for preventing damage. In 1936 he commenced work on the rat problem in Queensland canefields, and his researches in connection with this pest earned for him world-wide recognition. In 1949 he was transferred to the Department of Agriculture as Senior Entomologist.

In order that the Divisions of Entomology and Pathology might function more efficiently they were fused under the control of A. F. Bell in 1934. This led

to considerable staff reorganization and as a result Mungomery and Buzacott were assigned further work on the borer and grub problems, while McDougall later concentrated on rat control. Bell was responsible for calling the first conference of Cane Pest Boards in 1935 and this was the forerunner of the annual conferences of Cane Pest and Disease Control Boards which have done much to bring extension work up to date, and to improve the efficiency and economy of cane pest and disease control methods.

Buzacott worked on rind hardness as a factor in borer prevention and tested many of the newer insecticides against white grubs. In this connection he carried out most of the earlier tests with benzene hexachloride in 1945, when Mungomery was appointed to take charge of the Division, and the successful control of the greyback grub pest by means of this chemical has been brought about largely as a result of his initiative. In 1947 Buzacott transferred his activities to a study of sugar cane genetics, when he was appointed Senior Plant Breeder of this Bureau, and in 1948 G. Wilson was appointed in his stead to continue work on some of the white grubs which had not yielded so readily to treatment with benzene hexachloride.

In reviewing the work that has been accomplished over the years it is apparent that results were not always quickly forthcoming but nevertheless progress was sure, and with the means now readily available for controlling most of the major pests, newcomers to the industry need never fear the catastrophic

Grub-damaged cane near Gordonvale, 1949.

Grub-damaged cane near Cairns.

losses from pest attack which often confronted the earlier pioneers. Problems still exist and no doubt with changing systems additional problems will obtrude themselves from time to time, but with an organisation built up to meet such emergencies these problems should not prove incapable of ultimate solution.

Details in connection with control work in some of the more important pests are given hereunder:—

THE WHITE GRUB PEST.

Right from the earliest, following the expansion of the sugar industry in Queensland, reports featured very prominently the difficulties that various growers encountered in producing crops because of the activities of various white grub pests. With an incomplete knowledge of the different species that were responsible for this damage it was inevitable that considerable confusion should arise regarding their habits and life histories. However, it eventually became well established that the greyback grub, with a life cycle of one year, was the worst offender and that its distribution ranged from central Queensland to the extreme north. In the same area there were several other grubs whose period of development differed substantially, whilst other cane areas in the south were troubled by similar pests capable of causing heavy but localised damage.

Economic entomology had not advanced far in those early days when grub damage first became noticeable, and it seemed natural that growers should look for

relief by instituting a system of beetle and grub collecting. It was assumed that every grub or beetle caught and destroyed meant a reduction in the pest, and various Divisional Boards (or what we now term City or Shire Councils) were empowered to impose a levy on certain properties in order to finance the payment of a bonus for the beetles or grubs so collected. It can scarcely be claimed that such collecting was responsible for any diminution of the pest and from the outset Turner was one of the first to doubt its value. Later entomologists brought statistical evidence to discredit this method, and they condemned the system as contributing very little towards control. In view of this it is a matter for some surprise to realise that this system persisted with some Cane Pest and Disease Control Boards until comparatively recent years.

Girault realised that very little could be accomplished in the way of control until a complete knowledge of the life histories and habits of the pests was obtained. He concentrated on securing this information and devoted very little of his time to exploiting control measures. Illingworth saw the need for more extensive field experiments and he laid out several series of plots in the Meringa and Greenhill areas. He was of the opinion that much of the damage could be obviated by stimulating vigour in the plant so he attempted to increase tbe humus content of the soil and at the same time investigated the influence of artificial fertilizers. None of these was successful. He also had great confidence in the value of white arsenic applied in the cane drills, but although this gave some noticeable relief when relatively few grubs were present, even appreciable amounts of this chemical proved an utter failure when large infestations were involved. Jarvis also tried the effect of dusting Paris Green on the foliage of cowpeas and turning this crop under when young grubs or eggs were present in the soil. However, it proved impracticable to perform this work or any other form of deep cultivation in the young cane. The use of repellents and attractants was also investigated, but this line of attack yielded nothing of any value. This was not surprising in view of

Frenchi grub damage at Figtree Creek.

the extensive range of food plants utilized by the greyback beetle. The destruction of feeding trees was also attempted, but because of the inaccessibility of these trees on many of the nearby mountains and the fairly extensive flight range of the pest this plan never achieved its objective anywhere except perhaps in parts of the flat Burdekin area where in in recent years it has been used as a means of restricting the pest to the outer limits of some mill areas.

The value of late planting as a means of obviating grub attack was recognised by some of the earliest workers, while the use of resistant varieties capable of regenerating their root systems was fully exploited by succeeding entomologists as new varieties came to hand for testing.

Mungomery investigated three harmful species of white grubs in South Queensland and condemned lengthy ratooning practices. He recommended soil preparation during the summer months and developed the use of the high-speed rotary hoe for seed-bed preparation as the least

Frenchi grub damage at Deeral. Cane on both sides was treated with benzene hexachloride.

costly means of keeping these pests depressed at reasonably low population levels throughout the complete crop cycle.

Although various references to the possibility of satisfactory biological control were made by different entomologists, they apparently held out little hope of success in that direction because of the large number of native parasites and the equally imposing array of hyperparasites. Attempts, however, were made by Jarvis, on different occasions, to introduce wasp parasites from Java, but these introductions progressed little beyond the initial stages. In 1935 the giant American toad was introduced for the purpose of assisting in the control of various cane beetles, but in none of the areas in which it was liberated in Queensland did it achieve the same successes as were claimed for it from other sugar producing countries.

Soil fumigation with carbon bisulphide was attempted in the early 1900's before any entomologist had been assigned exclusively to the investigation of sugar cane pests. Results were erratic and this control measure was not popular. This is not surprising in view of the fact that the injectors were the cause of frequent trouble and constant attention or supervision was necessary to bring about worthwhile results. Jarvis experimented with paradichlorobenzene for some years and later, Freeman, of the Colonial Sugar Refining Company, used a mixture of this and carbon bisulphide with considerable success on Greenhill plantation. As a result soil fumigation received a great fillip and this practice was extended further with the formation of Cane Pest and Disease Control Boards in several of the larger mill areas in North Queensland. Well organised campaigns were undertaken annually, but in no season did the area treated exceed 2,000 acres, even though in many instances it was the only effective means of guaranteeing a crop fit for harvesting.

Grub damage therefore continued to fluctuate in accordance with seasonal conditions. In the meantime Mungomery and Buzacott, in an effort to find a better

Frenchi grub damage in foreground. Cane at rear received benzene hexachloride at rate of 150 lb. per acre of 10 per cent. dust.

First trial with benzene hexachloride at Meringa in 1946.

substitute for carbon bisulphide, explored the action of various new insecticides as they became available. One of the chemicals tested in this way during 1945 was gamma benzene hexachloride, and it immediately gave most spectacular and promising results against greyback grubs. Later experiments confirmed its value as a dependable grub destroyer. In more recent years Wilson continued research with this insecticide and it was subsequently determined that this chemical was able to persist for some years in the soil at a sufficiently high rate of concentration to kill grubs. Present day control measures, therefore, aim at applying sufficient of this insecticide in the drills after the young plant cane has germinated, to ensure protection over the normal cycle of three crops, and 150 lb. of 10 per cent. dust per acre fulfils this requirement.

This insecticide won instant appeal amongst cane growers because of its efficacy, its ease of application and its low treatment costs. Results secured on a commercial basis since 1947 have been truly remarkable, and as a consequence over 20,000 acres were treated last season. Doubtless larger areas will be treated in future years and losses will become progressively less. One thing, however, is certain and that is growers now have at hand a potent weapon whereby the greyback grub pest can be effectively controlled. Although the road to success was comparatively long, its ultimate attainment was none the less gratifying and not the least cause for this satisfaction is the knowledge that the savings effected by last season's B.H.C. treatments will alone amount to many times the money expended on all sugar cane entomological investigations in Queensland since their inception in 1911.

THE BORER PEST.

It is unfortunate that greater heed was not taken of some of the earlier warnings regarding the presence in New Guinea of a number of borer and other sugar cane pests whose accidental introduction into Queensland could be followed by disastrous consequences. In fact the beetle or weevil borer pest was already known to cause serious damage to cane in other sugar-producing countries, yet despite this knowledge large scale importations of borer-infested cane found their way at various times into New South Wales and southern Queensland. Fortunately, however, the imported material was usually in such bad shape and the borer damage so conspicuous that the canes were destroyed. The same elementary precautions were not long maintained, for it appears that later importations from New Guinea in the 1890's were responsible for the establishment of the borer pest at both Cairns and Mackay. Even after its establishment at these points little attempt seems to have been made to restrict its spread, and with the distribution and interchange of varieties it finally became established in most of the soft, succulent, noble canes. Its damage to some of the thick-barrelled types like Badila was so great at one

Effect of benzene hexachloride. Cane on left received 100 lb. per acre of 10 per cent. dust.

Illustrating the critical dosage of benzene hexachloride. Cane on right received 100 lb. per acre of 10 per cent. dust; that on left only 50 lb.

stage that it was considered as being second in economic importance to the greyback beetle.

Moir, an eminent entomologist who had carried out investigations on this pest on behalf of the Hawaiian Sugar Planters' Association, had succeeded in locating a Tachinid fly parasite of the same borer in New Guinea and on some of the adjacent islands. Intent on establishing the fly in Hawaii he realised that it would scarcely be practicable at that time to introduce the fly direct from New Guinea, so he used one of the borer-infested areas of Queensland as an intermediate breeding station. This was at Mossman, and there, in 1910, at the request of the Queensland Government, he liberated a number of his surplus flies. This resulted in the establishment of the Tachinid fly in Queensland.

Some attempts were made to reduce the borer pest by trapping and baiting, but results were not encouraging, and following the success of biological control in Hawaii it was only natural that efforts should be made to utilize the fly parasite more extensively in Queensland. Thus Illingworth introduced it into Babinda and other centres, whilst Jarvis later established fly breeding cages at Meringa and flies were liberated in all areas where borers were known to be present. Special small areas of borer-infested standover cane were left from time to time to act as sanctuaries, but in most instances the increase of the fly was slow and erratic, and the degree of control achieved never reached expectations.

This line of research was further investigated by Mungomery and Buzacott but they quickly came to the conclusion that the problem was in no way comparable with that in Hawaii insofar that the system of cropping in north Queensland was entirely different. This local system of cropping affected the host-parasite relationship and presented an insuperable difficulty, for whereas with the harvesting of the 24-months-old crops in Hawaii the fly was still able to find an ample supply of borer larvae in the 12-months-old crops and to maintain itself at a high population level, the reverse was the case in north Queensland. There, with the harvesting of twelve-fourteen months crops, little or no cane was left above ground after completion of crushing operations and the flies were unable to locate and parasitise any borer larvae. Hence each year the fly populations were decimated, whilst adult borers and their larvae in the underground portion of the stool were free to initiate fresh infestations. Thus it was abundantly clear that the north Queensland system of harvesting loaded the odds greatly against the fly, and favoured the pest, so attempts to improve biological control by means of this fly parasite were quickly abandoned.

Instead, investigations were then concentrated on determining the conditions which led to the heavy infestations periodically encountered, and these revealed that the unsatisfactory disposal of crop residues was largely responsible for this adverse state of affairs. In addition it became apparent that the high incidence of top-rot greatly favoured borer increase. Coupled with the use of hard-rinded varieties to mitigate the evil,

Persistence of benzene hexachloride into 2nd ratoons. Cane on right untreated.

a system of field sanitation and pre-harvest burning was recommended, and while this campaign was being instituted World War II. broke out. The resulting labour shortage made it imperative to burn all crops prior to harvest and this system of harvesting, adopted in the first place as a war-time expedient, has now become standard practice. This

Hodge hoppers on a corn cultivator used for benzene hexachloride distribution.

burning had an immediate and profound effect on the borer pest, and its numbers were so reduced that in many fields it is now difficult to find a single specimen. This state of affairs has been maintained over almost a decade, and it can be confidently asserted that this borer, which hitherto was of primary importance, has now been relegated to the position of a minor pest.

THE WIREWORM PEST.

For a number of years it was customary for growers to ascribe any damage to setts which prevented a normal strike as being due to wireworms, and since it is now known that a number of pests and diseases are capable of causing plant failures, it seems inevitable that there must have been much confusion in some of the earlier references to wireworm injury. However vague these earlier references may have been there can be no doubt but that wireworms did become pests of major importance in the central districts in the 1920's when large areas of poorly drained clay-bottomed soils were brought under cultivation following the expansion of the sugar industry about that time. Accordingly, in 1931, McDougall undertook the investigation of the wireworm pest at Mackay where the scope for this work was not limited in any way. He bred these pests through their various stages and came to the conclusion that one species chiefly was involved, and that it had a life cycle of one year. He investigated the use of various chemicals and quick acting fertilizers, but without effect, and finally recommended the permanent drainage of low lying fields and the judicious selection of planting times. Later on, from year to year, it was customary to issue warnings to growers regarding the probable intensity of wireworm attack, but in many cases these forecasts were ignored. It was realised that something more positive in its action was needed against this pest, and so, in 1946, when supplies of benzene hexachloride became available, opportunity was taken to test out this new insecticide. Excellent results were immediately secured and subsequently a technique was evolved whereby 10 lb. of 20 per cent. B.H.C. was mixed with 3 cwt. of an appropriate fertilizer, and this mixture, sufficient for one acre, was applied in the drill with the setts at planting time. In this way complete protection could be guaranteed at a cost of 14s. per acre for the insecticidal treatment. So effective has control been in the ensuing years that this treatment has become routine practice in all the low-lying areas of the central district and several thousand acres are treated annually. Thus another pest which defied effective control for a number of years, assumed an entirely different status.

THE RAT PEST.

Since 1910 rat damage in standing cane has been recorded from time to time. Infestations have been mostly scattered and spasmodic, and until 1933 efforts to combat the pest were local, empirical and based on overseas experience. However, a cause for wirespread alarm was an outbreak of Weil's disease in some of the northern cane districts during the rat plague of 1933-34, and since the causal

Grasshopper damage in young cane.

organism of this disease is carried by rats, this meant that the rat pest, in addition to its damage to cane, had to be regarded as a menace to the health of the cane cutters and other field workers. This prompted Gard, of the Colonial Sugar Refining Company, to institute immediately an extensive poisoning campaign in the Herbert River District, and the Health Department required cane to be burnt prior to harvesting. These actions have since affected all northern mill areas where rat control measures are now given constant attention.

In 1935, McDougall was assigned the task of investigating the rat problem in canefields. Three native species, a burrowing and two climbing rats, are mainly responsible for damage to cane. The ecology of two of these species has been studied in detail, and a considerable mass of information on the economics of the rat problem, rat poisons, poisoning and other methods of control is now available. This is used by Pest Board officers in formulating and carry out controls in the

Severe rat damage in Badila cane.

different districts. Poison baiting with packeted, thallous sulphate whole wheat at a strength of 1 : 300, or with yellow phosphorus on bread, is the most favoured routine practice.

DISEASE TRANSMISSION STUDIES.

A resume of entomological activities would scarcely be complete unless reference were made to investigations carried out in connection with the possible transmission by insects of sugar cane diseases. Mungomery, in conjunction with Bell,

Illustrating successful wireworm control by use of 20 lb. of 10 per cent. benzene hexachloride dust per acre mixed with fertilizer and applied in the drill at planting time. Rows on right and left were not treated.