who was then pathologist, interested himself in the transmission of both mosaic and Fiji diseases of sugar cane, and as a result of their researches they were able to demonstrate that the sugar cane leafhopper was the vector responsible for the spread of the latter disease.

Control measures, which have since been applied with considerable success, took cognisance of their findings in respect of leafhopper incidence and the period of the pest's greatest increase, whilst in other instances the liberation of infective leafhoppers has been used as a means of speeding up infection in field trials established for the purpose of determining the degree of susceptibility or resistance of new varieties.

Insect transmission studies were also undertaken in respect of dwarf and chlorotic streak disease, but nothing of a positive nature has yet been obtained from these experiments.

**Damage to young Badila caused by attack of army worms—*Cirphis sp.***



# Sugar Cane Pathology and Disease Control in Queensland.

By C. G. HUGHES.

**Mr. C. G. HUGHES, Pathologist.**

## INTRODUCTION.

The recommendation of the Queensland Secretary for Agriculture, in 1899, that the services of a specialist be secured to inspect and give advice upon the local sugar industry did not mention the possible reasons why "the best results are not obtained from the cane fields," but it is probable that losses due to disease had had some influence in initiating the step taken. In the press of the day there were many references to poor yields on once-fertile soils, and susceptibility to diseases unspecified seemed to be a feature of the failing crops. Apart from these expressions of opinion it is known definitely that during the nineties there was a serious outbreak of gumming disease in the Bundaberg district. Mr. Henry Tryon—the same person who was a little later to collect Badila from New Guinea—was then Entomologist and Vegetable Pathologist of the Department of Agriculture and was assigned to investigate it. He visited the Wide Bay and Burnett District during the crushing in 1894 and reported losses over wide areas; there is no doubt that the disease was causing some concern. Another disease, now realized to be red rot, was at the same time causing losses in millable cane in some of the northern districts, particularly Mackay. There was no general disease consciousness on the part of the growers but there is no doubt that loss due to disease was one of the important obstacles to successful cane cultivation.

The specialist appointed, as mentioned elsewhere, was Dr. Maxwell, of Hawaii, who later became the first Director of Sugar Experiment Stations. His report includes a section, about one-tenth of the whole, on pests and diseases and makes several other references to diseases, but his general attitude was that an impoverished soil and a weak and debilitated crop provided all the desiderata for the development of disease. Despite the fact that Dr. Cobb, the Pathologist to the New South Wales Government, had recently found gumming to be due to an organism, Dr. Maxwell thought that the disease should be attacked from the double standpoint of the soil and the seed and he left no doubt as to which he considered the most important. The application of these principles had an interesting result some years later when he had established on the Mackay Sugar Experiment Station a "hospital" for cane varieties which were diseased. They were planted in virgin soil, a little apart from other cane and were to receive the best possible conditions. The varieties were from the Tryon collection of 1896 and other sources and, during growth on the Station, had become so badly infected with "apparent forms of disease and debility" that it was impossible to

judge their agricultural worth. The patients did not respond as expected, for there was a good deal of gum in the hospital plot in the plant crop; the first ratoon was worse, and in the second ratoons it was reported that the canes, so far from recovering, had gone from bad to worse. This experience was unhappily repeated in commercial plantings in many parts of Queensland before the disease was brought under control by modern resistant varieties.

**Typical Dwarf disease infection in P.O.J.2878 at Mackay.**

### EARLY DISEASE HISTORY.

There is mention of gumming disease interfering with a Bureau cultivation-cum-manurial trial on a farm in the Herbert River district in 1902 and at the same time a disease which was probably downy mildew was causing some losses in a variety known as Violet in the same district. Trial and error substitution of varieties appears to have exercised an effective control over gumming disease and it was not until 1920 that the disease in commercial plantings led to a remark in the Director's Annual Report that gumming was seen in many places on the Herbert, notably in connection with the variety known as Clark's Seedling. During the next few years increasing losses due to gumming in various districts led to a general increase in disease consciousness, so that in the 1923-24 Bureau Report there is the first appearance of "Disease" in a sectional heading and, in the same Report, an announcement of the selection of a graduate of Queensland University to go abroad to study "Plant Pathology as applied to sugar cane." The graduate selected was A. F. Bell, who spent some four years in study abroad and returned to take charge of the pathological work of the Bureau and eventually became Director. In 1924, the first comprehensive survey of disease and cane pests in the different districts was carried out by W. Cottrell-Dormer; the survey was repeated in the following two years. The results of the surveys are of interest as representing the basic work for the control of cane disease and also for comparison with the position at present, just 25 years later.

In the far North a local infection of gumming disease at Aloomba, in the Mulgrave area, led to quarantine measures and to a recommendation that resistant varieties only be grown. This outbreak did not spread at the time but apparently was not eliminated because a decade later it acted as a source of infection in the widely grown, very susceptible S.J.4. On the Herbert, gumming was serious in Clark's Seedling (H.Q.426) and the Goru canes, but control of plantings and the elimination of susceptible varieties brought the disease under control and except for some infection on the Ingham Line in the late thirties, it has not been seen in the district since. There was some gumming disease at Mackay at this time; for instance it interfered with a varietal trial on the Experiment Station by badly affecting H.Q.285 and E.K.28, but the disease reached its peak in the more southerly districts, where the susceptible D.1135 had become such an important cane. Losses were district-wide at Bundaberg, in the Isis and at Moreton, where a farmers' meeting was held to discuss it and to establish a source of clean plants as a control measure.

Leaf-scald disease had reached epidemic proportions in North Queensland where Badila was obviously less susceptible than H.Q.426, Pompey or the Gorus; it was also recorded for the first time on the Maroochy River. Top rot was noticeable from the Burdekin north and occurred in small amounts elsewhere. Red rot was serious in the Mackay district, particularly in M.1900S. and M.189. Mosaic was widespread in South Queensland and there were isolated occurrences in the North. Downy mildew, which was then generally called "leaf stripe," occurred in a number of centres and Cottrell-Dormer, in 1924, remarked prophetically that this disease promised to be one of the most difficult to control without the loss of valuable varieties. It occurred at Mossman in nearly every field of B.147; it was damaging Pompey in the Hambledon area, was present in the wetter Babinda-Tully area and was to be found in most fields of B.208 on the Burdekin. At Mackay and Proserpine it was showing in P.O.J.2714 and several other varieties and in the Bundaberg district occurred in the Woongarra and at Bingera.



### FIRST RECORD OF FIJI DISEASE IN QUEENSLAND.

At the beginning of 1926 Fiji disease was recorded by N. L. Kelly as being present at Maryborough and Beenleigh. It had apparently come from New South Wales in importations of cane made by farmers, but the extent of the outbreaks and conversations with farmers led to the conclusion that the disease may have been present for several years before it was found by a pathologist.

In 1927, some suggestions for the control of cane diseases which were later to form the basis of the legislative control work in Queensland, were put forward by E. J. Ferguson Wood. He suggested that the cane-growing areas of the State should be divided into a number of quarantine districts, that there should be a practical field man stationed at each mill to supervise planting material, distribution of varieties and eradication of disease, that there should be established variety plots under proper supervision at each centre and that only a few proved varieties should be permitted to be grown in each district and the rest prohibited, unless special permission were obtained.

**Devastation casued by Fiji disease in the variety D.1135.**

### BEGINNING OF PATHOLOGY DIVISION.

In 1928, A. F. Bell returned from overseas and was appointed to control the newly constituted Division of Pathology. The first report of the Division showed that Fiji disease had spread to Bundaberg and Moreton and that lists of disease-free farms at Beenleigh and Maryborough had been published in order that farmers might purchase plants from reasonably safe sources. Similar steps were initiated at Farleigh, near Mackay, for mosaic disease, and at Bundaberg and Nambour for gumming. As one of the first measures against disease a large number of varieties was imported from overseas. Those from Java included P.O.J.2878 and several other high numbered P.O.J. canes. The batch of 65 canes from Hawaii included varieties which, from their breeding, could be expected to be resistant to gumming, but none ever became commercially important.

The five years ending in the latter half of 1933 saw a tremendous increase in the activities of the Pathology Division, but at the same time there were developments in the field which made these imperative if cane growing were to be continued as a profitable industry in certain districts. In South Queensland gumming disease was easily the main pathological problem. The very dry spring of 1929 caused severe losses over wide areas, particularly in the drier localities about Bundaberg. The damage caused then was probably as serious as in any outbreak of the past

and it was fortunate indeed that succeeding favourable seasons prevented undue losses while the new gumming resistant canes were being multiplied to the stage of commercial propagation. Fiji disease continued to be a major problem in the Maryborough district and had extended at Bundaberg; the outbreaks at Childers and at Bingera further justified the importance attached to this disease. The disease known first as "pseudo-scald" but now called chlorotic streak was recorded at Proserpine in 1929 and seen subsequently in many varieties in the North. A small trial in Brisbane indicated that the disease caused serious losses in Badila. Dwarf disease was found at Mackay in 1930. It occurred chiefly in P.O.J.2714, although P.O.J.213 was also affected. This was a disease new to the sugar-cane world and some alarm was felt when it was found on several farms. Fortunately, however, it has been fairly easily controlled.

### SEARCH FOR GUMMING RESISTANT VARIETIES.

The staff of the Pathology Division during this period consisted of A. F. Bell, W. Cottrell-Dormer, E. J. Ferguson Wood and N. L. Kelly. It was fully occupied on field and investigational work, the results of which were of benefit to overseas workers as well as the cane growers of Queensland. Importations of canes continued, even though a suitable insect-proof quarantine house had not yet been built and the new canes had to be propagated in open quarantine. The urgency of the demand for gumming resistant canes warranted the risk being taken and, as far as it known, there was not a single case of a disease from overseas getting into the country per medium of these introductions. By the end of 1933 the gum-resistant canes, Co.281, Co.290, P.O.J.213, P.O.J.234, P.O.J.2725 and P.O.J.2878, as well as many others which did not reach commercial prominence, were ready for trial or use on farms. It was realized that importations would not always provide the most suitable canes, and seedling raising was commenced at each of the Experiment Stations. Some success had already attended seedling raising at South Johnstone and the S.J. series was to become well-known. At the present day S.J.4 is still an important cane in Mossman and S.J.16 is popular on the Burdekin. The cane-breeding was not then carried out by the Pathology Division but was under its direct supervision. In later years the close association between pathology and cane breeding was emphasized when C. G. Hughes had charge of the crossing work and took an active part in seedling selection. At the present time a separate

**Severe stunting caused by a *Sclerospora* fungus.**

**The cane killing weed—Striga sp.—growing amongst stunted stools of cane.**



breeding section has been established but there is at all times close liaison between the cane-breeders and the pathologists and no new seedling is released until it has been passed through disease resistance trials.

### DEVELOPMENT OF CLEAN SEED SCHEMES.

Many district surveys were carried out during 1928 and 1929 in order to locate disease-free farms as sources of clean seed, and just prior to the widespread planting of the gum-resistant canes more than 6,000 tons of clean seed had been provided in the Bundaberg area alone. The clean-seed scheme naturally was not needed when the major diseases were brought under control by resistant varieties but within recent years it has been revived in a modified form, and of course against different diseases, by the supervisors of the Cane Pest and Disease Control Boards. In the Mulgrave area, for instance, close supervision of plants being used in the leaf scald and chlorotic streak danger spots has recently effected a big improvement in the disease situation, and similar activities in the Mackay and Moreton areas have been an integral part of disease control.

An isolation plot in which small amounts of a large number of varieties could be grown under close observation was established in 1930 on Stradbroke Island in Moreton Bay. This disease-free site acted both as a museum of varieties and as a source of plants for particular purposes such as export to other countries, or for disease resistance or investigational trials. Later, the variety garden was transferred to the mainland at Lawnton about 18 miles north of Brisbane. It is now on the property of the Queensland Acclimitization Society at Redland Bay, a vegetable-growing area of volcanic soil, on Moreton Bay. There are at present 121 varieties in the plot.

### LABORATORY RESEARCH.

The research work of the Division was advanced by the establishment of well-equipped laboratories at Brisbane in the river-side building of the Department of Agriculture and Stock. The advantage of siting the laboratories in the capital city, where scientists in other branches of the Government service and the University could be contacted are obvious, even though the situation would not permit of the establishment of an adjacent cane paddock. This difficulty was removed by the acquisition of a reserve of three acres, less than half a mile from the Head Office. The plot is not affected by frosts and is served by city water. Not more than an acre has ever been used but this small plot has proved invaluable for pathological research. It is planned to build experimental glass houses on the plot in the near future, when much of the work formerly done there will have been transferred to an area of cultivation at Moggill, some ten miles from the city.

**The effects of "droopy-top"—a deficiency disease at Nambour.**

**Chlorotic streak yield trial. Truck on left from healthy plants and that on right from diseased plants.**

**Planting a downy mildew resistance trial. Note isolated location.**

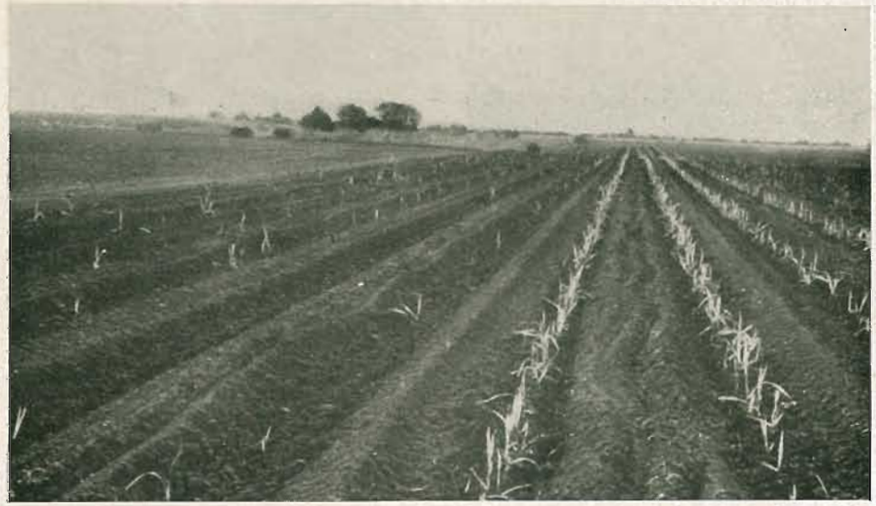
### DISEASE RESISTANCE TRIALS.

The testing of varieties for resistance to disease was one of the most urgent jobs which the newly constituted Division had to tackle. The technique had to be worked out immediately for gumming disease and soon afterwards for Fiji disease. The problem was to test the varieties as quickly as possible, often with the minimum amount of planting material, and to obtain results which would allow an accurate forecast of behaviour when the new canes were propagated on a field scale. The first properly planned gumming resistance trial and the first for any disease in Queensland was planted on Bundaberg Sugar Experiment Station in September, 1928. It was designed chiefly to furnish information on the size and complexity of trial required but unfortunately was destroyed by heavy frosts. The trial planted in the following year gave excellent results although much simpler in layout. The first leaf-scald trial was planted at South Johnstone in spring, 1930, followed by a red-stripe trial at Mackay in 1932, a downy mildew trial at Ayr in 1933 and the first Fiji trial (which had been delayed owing to lack of knowledge of the vector) at Eagleby in the same year.

Concurrently with the field work a considerable amount of research was undertaken and, apart from numerous items in the "Queensland Agricultural Journal" and Annual Reports, several papers were published. The first and in many ways the most important was bulletin No. 2 of the Division—Bulletin No. 1 was a printing of a report by H. Tryon on work done on top rot in North Queensland in 1903. This Bulletin No. 2 was A. F. Bell's "A Key for the Field Identification of Sugar Cane Diseases" compiled as a result of his studies abroad. It was widely distributed in Queensland and served to bring diseases to the notice of farmers and mill officials alike. Bulletin No. 3 was published in 1932 and included an article on dwarf disease, another on the cane-killing weed and the first comprehensive account of top-rot disease. The latter, which was by W. Cottrell-Dormer, included field and laboratory studies. Bulletin No. 4, entitled "Fiji Disease of Sugar Cane and its Transmission," by R. W. Mungomery and A. F. Bell, appeared in 1933. It marked an important addition to our knowledge and was the basis for the design adopted in the resistance trials for this disease. Other important work, the results of which were not always published, included the establishment of the fact that gumming disease could not be transmitted per medium of the soil, the development of a medium for the cultivation of the fastidious *Xanthomonas albilineans*, a varietal identification scheme based on a simplified Jeswiet system, the separation of mottled stripe disease from red stripe and laboratory studies on the variability of cane pathogens.

**A downy mildew resistance trial at a late stage.**





**Germination failure on left is due to pineapple disease. Setts used for planting on the right were dipped in a mercurial solution.**

### LEGISLATIVE MEASURES FOR DISEASE CONTROL.

It was soon apparent that the measures required for the control of disease on the several thousand cane farms in the State needed strong legislative backing if they were to be effective. The first important legislation enacted for the specific purpose of controlling disease in cane was the proclamation under *"The Diseases in Plants Act of* 1929," whereby nine sugar-cane quarantine districts were defined. The aim of this was to prevent the free movement of cane plants from one part of the State to another. It meant that all transfers, except of cane for milling purposes, had to be channelled through the Bureau and were therefore under strict control. These quarantine districts, with the addition of another one formed by the cutting off of the Mossman area from the northernmost district, are still in force although the proclamation operates under a different Act. Farmers could still, however, plant any variety they fancied and many were a menace to their neighbours by maintaining a miscellaneous collection of susceptible varieties. The introduction of the approved variety system was initiated by an amendment to the Regulation of Sugar Cane Prices Act in 1934. Under this the Director of Sugar Experiment Stations issued a list to the Local Cane Prices Board in each mill district, which then designated any or all varieties in the list to be approved varieties. The Board could not approve any varieties apart from those on the

**Another type of mercurial dipping plant employed against pineapple disease.**

**Removable planter box for mercurial dipping of cane plants as protection against pineapple disease.**

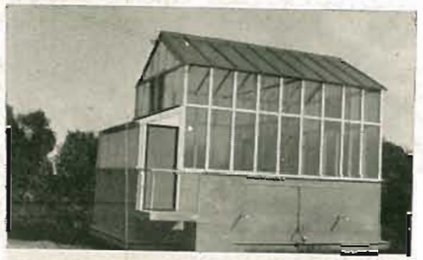
Director's list. The penalty for delivering a variety not approved to the mill was a flat rate deduction of ten shillings per ton of cane. This was the position until the major amendment of the Sugar Experiment Stations Acts in 1938 by which the Director issued an annual list of approved varieties under these Acts; varieties not included in this list were prohibited. The grower is now liable to a heavy fine for growing, and the miller for accepting, cane of a variety not on the approved list. It is worth noting that of the three features which the Director is required to take cognisance of for the purpose of deciding approval or not, the first mentioned is resistance to disease; agricultural qualities and milling characteristics are the other two.

Apart from the establishment of the approved variety list on a firm basis, the 1938 amendment, together with various minor amendments incorporated in subsequent years, strengthened the Acts considerably as a means of controlling disease. They were designed specifically for sugar cane and the crop was removed from the effects of any other Act or Acts. Power was given to prevent the growing of varieties for longer than the second ratoons when disease was present; a list of diseases against which action could be taken was proclaimed; provision was made for the destruction of sugar cane, which, although not itself diseased, might have assisted in further spread of a disease; quarantine areas within portions of a mill area could be enforced; farmers were required to give notice of the appearance of a disease on their properties, and, most importantly with regard to the machinery of controlling disease, the cane pest and disease control board system was instituted. The amended Act gave the Director, either directly or indirectly by advice to the responsible Minister, very wide powers, and heavy penalties were provided for breaches.

## CANE PEST AND DISEASE CONTROL BOARDS.

The Cane Pest and Disease Control Boards were set up in each district where the pest or disease position warranted it and at present there are 21 boards in existence. Each Board has five members, two of whom are elected by the millowners and three by the cane growers. There is no government nominee on the Boards, although in practice there is very close co-operation between Bureau officers and the Board members and staffs. The Boards have a large measure of autonomy but are under the general supervision of the Bureau and their accounts are subject to inspection by the Auditor-General. The establishment of the Boards as working units devolved upon the members of the pathology and entomology staff who trained Board employees in the detection of disease and were always available for consultation and help in any emergency. In most areas it was not possible to control disease merely by the substitution of resistant varieties and many somewhat susceptible varieties were grown, which necessitated extensive roguing campaigns in the commercial crops. The Bundaberg district was, and still is, an example of this. The variety P.O.J. 2878, for instance, is quite resistant to gumming disease and that disease ceased to be of any consequence when





**Quarantine house for imported canes at Brisbane.**

that and other canes supplanted the older varieties. However, P.O.J.2878 is susceptible to both Fiji and downy mildew diseases and it was only the constant inspection and roguing by the Board gangs which allowed these diseases to be held in check until a new, more resistant cane, C.P.29/116, was propagated. These inspections are planned firstly to detect any outbreaks of disease, and secondly to control any outbreaks found. The scale of operations is quite impressive in some districts; at Mackay up to 45,000 acres were inspected in one year, at Bundaberg 35,000, and in the much smaller Moreton area 4,500 acres. The work is financed entirely by local funds and the individual contributing farmers and millers take an interest in the Board's work. The Boards have a flexibility of management and detailed knowledge of local conditions which would be very difficult to achieve in a Government department and as a virtual extension service of the Bureau are an important adjunct to its functions. Subsidiary to the direct control of disease are several other aspects of the Boards work which are quite important; some, for instance, conduct isolation plots for the introduction of varieties supplied by the Bureau; others have quite extensive clean-seed schemes in operation and others again take an interest in the propagation of new varieties in their districts.

## RECENT WORK OF DIVISION OF PATHOLOGY.

At the time of the amending Act of 1938 the Bureau pathology staff consisted of A. F. Bell, C. G. Hughes and D. R. L. Steindl, with C. W. Leece as technician in the laboratory. Field work was combined with research and at about this time was published a Technical Communication on alternate hosts of *X. vasculorum* by C. G. Hughes, one on legume inoculation in Queensland canefields by D. R. L. Steindl and "Downy Mildew Disease of Sugar Cane and Other Grasses," by C. W. Leece. The 1939-45 war put a stop to all pathological activities except those necessary to prevent diseases causing or likely to cause serious losses in production. At the end of the war A. F. Bell relinquished his position as officer in charge of the Division of Entomology and Pathology (the two divisions had been fused into the one in 1934) and was succeeded by R. W. Mungomery. Leece had already resigned and Messrs. Hughes and Steindl, later assisted by a cadet, carried on the pathological work.

Recent developments in the pathology field include the working out of a practical method for the control of pineapple disease and research into the ratoon

**Hot water treatment plant for chlorotic streak disease.**

**Ratoon stunting disease on left. Healthy cane on right.**

stunting disease. Pineapple disease is always likely to cause serious trouble when the plantings have to be made in the cooler months, and has been particularly severe in the Lower Burdekin area. Treatment of the setts prior to planting by dipping in a solution of mercurial compound exercises a complete control and in the worst affected areas the treatment has become a general practice. A Farm Bulletin has been published giving practical details. The research into ratoon stunting disease has revealed that the lack of vigour in the ratoon crops, and to a lesser extent in the plant cane, is due to a transmissible disease probably caused by a virus. It is possible that the studies on this disease will indicate the true reason why many varieties are notoriously poor yielders in the ratoons and why some varieties have been considered to run out; both are problems of general interest to cane sugar producers throughout the world.

**Ratoon stunting disease. Cane on right is healthy.**

## PRESENT DISEASE POSITION.

The history of the pathology section would not be complete without some account of the important diseases which have had to be contended with in the various districts during the years since active control measures have been undertaken. Commencing in the far North at Mossman, leaf scald and chlorotic streak are present, but downy mildew, which had been recorded there for many years, appears to have been eradicated, whilst gumming disease, although causing the abandoning of the variety S.J.4 in a large part of the mill area, has been brought under control.

At Hambledon, near Cairns, the substitution of the susceptible S.J.4 and H.Q.426 by more resistant varieties has eliminated gumming disease but has brought a new degree of susceptibility to downy mildew to the district. A recent localized outbreak of this disease did occur but a vigorous roguing campaign prevented its spread. It is as yet too early to say that the disease was eradicated since the last diseased stool was found only in April, 1949.

In the Mulgrave mill area gumming caused the loss of S.J.4 and H.Q.426, as in the neighbouring Hambledon area, but the disease has not been recorded for some years now and steps have already been taken to re-introduce these varieties. Leaf scald and chlorotic streak, companion diseases of the wetter lands throughout the north, are being kept under control at Mulgrave by strict control of the sources of plants.

From Babinda to the Herbert River, leaf scald and chlorotic streak occur in varying amounts depending on the locality and variety; where active steps have been taken these diseases are under control. On the alluvial soils of the Lower Burdekin where downy mildew was so serious in B.208 two decades ago, the disease has been eradicated and this variety together with the susceptible S.J.16 are popular canes. Mosaic disease is under control and the dipping of plants in a mercurial solution has guaranteed satisfactory strikes in fields subject to pineapple disease.



**Ratoon stunting disease affecting Q.50. Note normal cane on left.**

In the Mackay district where the one pest and disease control board attends to the cane lands of six mills, downy mildew was brought under control, so allowing the susceptible P.O.J.2878 to become again a major cane. Dwarf disease occurs only in small amounts. Mosaic disease is present and ratoon stunting, which can be controlled by supervision of the sources of plants, is fairly widespread. The new but already important and popular cane, Q.50, is susceptible to red rot, which has been responsible for the discarding of Co.290; it remains to be seen whether Q.50 will also succumb to the disease. The cane-killing weed occurs sporadically at Mackay.

In the Bundaberg district the eclipse of the gum-susceptible canes such as D.1135 and M.1900S. was followed by the widespread planting of P.O.J.2878, Co.290 and other resistant varieties. Co.290 lost favour chiefly on account of red rot, while downy mildew and Fiji diseases were kept under control reasonably well in P.O.J.2878 until the advent of C.P.29/116, which subsequently became the major variety. Except for a moderate degree of susceptibility to Fiji disease, C.P.29/116 appears to be resistant to the other diseases of South Queensland and its continued cultivation on the present extensive scale is very desirable from the

**Ratoon stunting disease in a field of Q.28.**

One of the Turkmenistan hybrids growing in the quarantine house.

disease point of view. Rind disease which is normally a disease of over-ripe cane is likely to cause some damage in some of the newer southern varieties. Ratoon stunting disease is present but the elimination of Q.28 should bring it under control.

Maryborough, which was once the scene of the most severe damage due to Fiji disease ever seen in Queensland, has been cleaned so thoroughly that the susceptible variety M.1900S. is now restored to the approved list. Chlorotic streak has been recorded at Maryborough but is apparently not doing any damage. In the Moreton mill area, as at Bundaberg, gumming was brought under control by the use of P.O.J.2878 and Co. 290. However, Fiji disease could not be controlled by roguing in P.O.J.2878 and the variety has gone out of favour while Co. 290 suffered severely from red rot. The newer canes such as C.P.29/116, Q.28 and Q.47 are being watched closely in respect of both Fiji and chlorotic streak diseases. The small area of Rocky Point, between Brisbane and the New South Wales border, has some Fiji and chlorotic streak disease.



# A Short History of Bureau Cane Breeding.

By J. H. BUZACOTT.

Mr. J. H. BUZACOTT—Senior Cane Breeder.

Botanists and other scientists working on sugar cane are agreed that the probable centre of origin of the species of *Saccharum* which have given rise to the commercial canes of the world, is in the south-east corner of the Asian continent and in the string of islands extending through the East Indies and out into the Pacific Ocean. It is remarkable therefore that Australia, which is only about 100 miles from New Guinea across Torres Strait, has not a single indigenous cane of any sort. There are none of the wild canes found growing in dense thickets in New Guinea and the aboriginals have never cultivated any of the canes found in the gardens of the New Guinea natives. Perhaps the firestick and the general improvidence of the nomad natives have been responsible, but whatever the cause the lack of ready-made varieties has meant that all canes for the establishment of the sugar industry had to be brought from overseas. Australia is of course not unique in this respect, for sugar cane does not occur naturally in either North or South America and only a useless type occurs naturally in Africa.

The pioneers of the sugar industry in Queensland were very much alive to the necessity for obtaining a range of varieties and from 1863, when Captain Louis Hope with a planting of 20 acres near Brisbane, established the first commercial plantation in Queensland, until the turn of the century nearly 300 varieties were imported from all parts of the world. The farmers, plantation owners and government officials alike were certainly variety conscious; it is to be regretted that the knowledge of cane diseases was not sufficiently advanced for them to be disease-conscious also, for with the new varieties came disease and subsequent serious losses in later years. Australian growers drew upon the cultivated varieties of many countries for their importations and, in addition, collections were made for the first time in New Guinea. The canes brought back from that island had been selected by the natives over many centuries for chewing and were, as a rule, fairly thick, sweet and soft-rinded. The first search was undertaken by Ebenezer Cowley, an officer of the Queensland Department of Agriculture, in 1893. He brought back ten varieties none of which ever became an important commercial cane. The second expedition, in 1896, was led by Henry Tryon. He collected 72 clones including the famous Badila, as well as such canes as Mahona and the Gorus, which in certain places have enjoyed some popularity. For many years Badila provided more than half the crop north of Townsville and has only very recently been displaced from its position as the variety yielding the greatest proportion of the total Queensland crop.

**Mr. J. MITCHELL, who collected seed and raised seedlings for the Queensland Acclimitisation Society.**

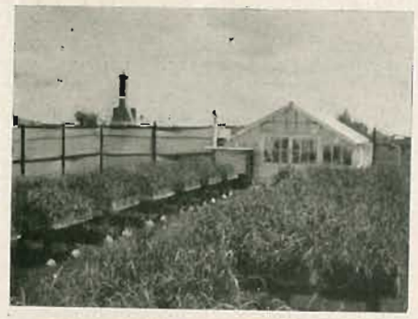
The degree of improvement in production which can be obtained by the importation of varieties is limited when there is no stream of new improved varieties coming forward. Fortunately it was soon found that a continual supply of new varieties could be provided by seedlings, although the fact that the widely grown Creole cane was sterile had led many to believe that sugar cane would not set seed. The fertility of cane flowers was demonstrated as early as 1858 and during the next few years seedlings were grown at centres as far apart as the British West Indies and Mauritius. However, the importance of the discovery was not generally realized and it was not until 1888 when Soltwedel in Java and Harrison and Bovell in Barbados produced cane seedlings, that modern cane-breeding can be said to have commenced. In the same year W. Soutter, Manager of the Gardens of the Queensland Acclimitization Society, then at Bowen Bridge, Brisbane, raised four seedlings from the variety China. In the following year seedlings from five different varieties were raised.

The Society continued its cane-breeding activities until 1908 and, considering the limited facilities and the unfavourable climatic conditions, was remarkably successful. One of its seedlings, Q.813, was grown in many districts in Queensland and as recently as 1935 produced more than 10 per cent. of the Mackay crop. In the early years of the century the Colonial Sugar Refining Company also raised some seedlings at Hambledon, near Cairns. Among the varieties which became prominent were H.Q.285, H.Q.409 and H.Q.426; the last-named is still grown in North Queensland, chiefly on account of its early maturity. The company has continued its seedling raising and now conducts a station at Macknade, North Queensland.

Several attempts were made by the Bureau to obtain seedlings from arrows picked at Mackay Experiment Station but without success. In 1918, however, a new Station was acquired at South Johnstone, near Innisfail in the tropical wet belt in North Queensland, and the Chemist-in-Charge, P. McWalters, was quite successful in 1921 in raising seedlings from the local fuzz. In the first year some 736 seedlings were planted out into the field. By 1928, when E. J. Barke was appointed to succeed McWalters, the annual plantings had risen to several thousand, the actual number depending usually on the success of the crossing season. During the first few years seedlings were obtained from arrows naturally pollinated in the field. However, an investigation into the fertility of sugar

**Glasshouse for seedling raising at Meringa Experiment Station.**





**Potted seedlings outside glasshouse at Bundaberg.**

cane flowers at South Johnstone by W. Cottrell-Dormer led to the adoption of a system of controlled pollination in 1926 and at the same time use was made of a dilute solution of sulphurous acid for the maintenance of male arrows during the pollination.

As has happened so often in the history of cane-breeding the first batch of seedlings yielded some excellent commercial canes. Arrows collected in the field from Badila produced, among others, seedlings which eventually became well known as S.J.2, S.J.4 and S.J.16. The first, S.J.2, is a moderate yielder with a very high sugar content and in certain parts of the Ingham, Burdekin and Mackay areas has given very good returns. It was eighth on the list of important canes in Queensland in 1942. S.J.4 became a very important variety in North Queensland in some mill areas. At Mossman it yielded over 70 per cent. of the tonnage crushed in 1946; at Hambledon in 1940 it yielded two-fifths of the crop; at Mulgrave it was second only to Badila for some years and between 5 and 10 per cent. of the Innisfail crop even now consists of this variety. It lost favour when gumming disease appeared in it but is still regarded as a good cane and is being re-introduced at Mulgrave now that gumming disease has apparently been eradicated. S.J.16 has been tried in various districts and appears to have found an important place in the crops of the Burdekin. In 1949 it yielded 17 per cent. of the cane crushed there.

In 1929 attempts made to raise seedlings at Mackay and Bundaberg from fuzz from South Johnstone were a failure. In the following year, however, heating frames were provided and some reasonably satisfactory germinations obtained. They were supplemented by some seedlings sent from South Johnstone and more than 1,000 seedlings were set out at each station. The extension of seedling raising to the other stations coincided with the first use as parents of the newly-introduced P.O.J. and Co. canes. Seedling raising has, with a minor interruption at Bundaberg during the war, continued ever since as a major part of the operations on both stations. Within the last twelve months an experiment station has been founded at Ayr and seedlings will be raised there this year.

It was soon realised that the hazards associated with the production of cane seed at South Johnstone were too great for that centre to become a permanent breeding station, and in 1930 plantings of parental canes were made on a farm at Freshwater, to the north of Cairns. Crosses made there in 1931 proved that the new site was superior to the old, especially with regard to the reliability of the arrowing, and by 1935, when the breeding station was transferred to the Northern Experiment Station at Meringa, near Gordonvale, all crossing was being undertaken at Freshwater. There was no immediate attempt to build up a varietal garden at Meringa and for the next few

**Potting seedlings at Mackay. Note flags to frighten grasshoppers.**

**Flats of young cane seedlings in Meringa glasshouse.**

years the crossing work remained confined to the Freshwater plantings. Before the transfer from South Johnstone, E. J. Barke visited Java to investigate the cane breeding methods in use there. In addition, an importation of fuzz, the only one on record for Queensland, was made from Hawaii. The resultant seedlings were not a commercial success although one cane, the parentage of which unfortunately was lost, became Q.27 and has proved a useful parent for North Queensland.

The extension of seedling raising on a fairly large scale to the three stations meant that buildings and equipment had to be provided at each centre. The Meringa glasshouse which measures 18 feet by 60 feet is the largest of the three and was built in 1935. That at Bundaberg was finished in 1936 and the Mackay one in 1938. Each house is equipped with a hot water boiler and heating pipes, benches mounted on castors for easy shifting when loaded with seedling flats, and provision for maintaining a high humidity without excessive temperatures on sunny days. Associated with the glasshouses are steam flat sterilizers, compost pits, soil-mixing sheds and concrete benches for the young potted seedlings. The new station at Ayr is now in process of being equipped in a similar fashion.

**Seedling flats covered with glass in Meringa glasshouse.**

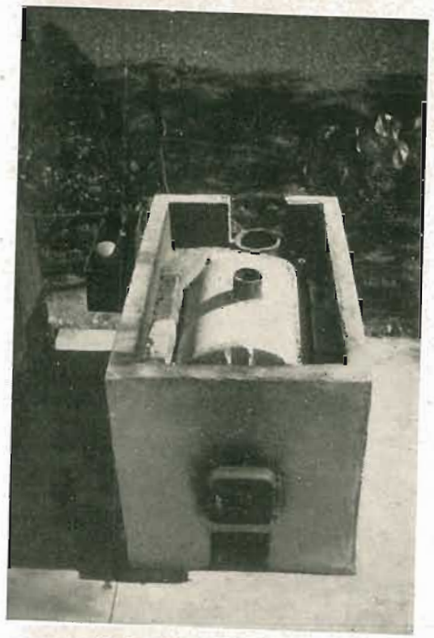
During the course of the next ten years a considerable amount of research was undertaken by the Committee on Seedling Raising which consisted of the Assistant Director (A. F. Bell), C. G. Hughes (Pathologist), and the Officers in Charge of the three Experiment Stations. This work included investigation into methods of cross pollination and at the same time a satisfactory scheme of selection of the seedlings was developed.

**Arrows being transported to crossing field.**

The results of the work have been set out in a Technical Communication, "The Production and Testing of Sugar Cane Seedlings," by C. G. Hughes, published in 1949.

It was obvious that the complete solution method, in which both males and females are maintained in solution, had many advantages over both open-pollination and the method in which the female





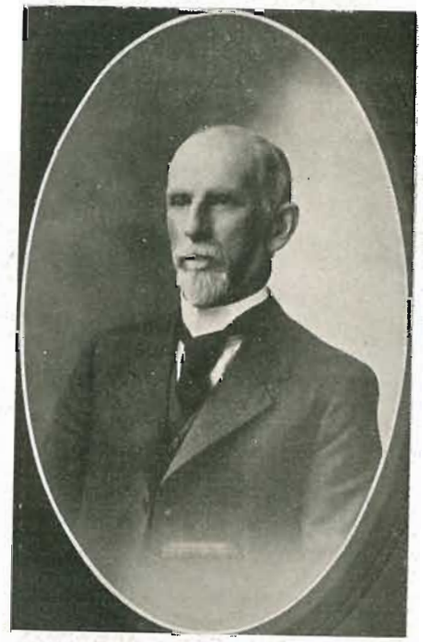
**Soil sterilizing boiler. These are used at all stations for sterilizing seedling flats.**

arrow sets and ripens seed whilst still attached to the stool in the ground. The all-solution technique allows the concentration of all crosses in a comparatively small area so that they can be easily kept under close observation during all stages from pollination to the picking of the seed.

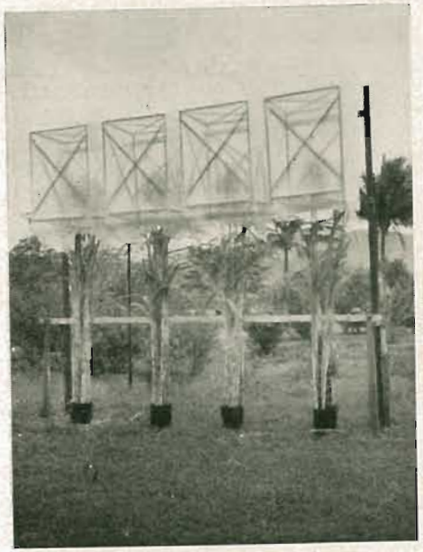
Experiments showed that the most suitable solution was a mixture of .01 per cent. sulphur dioxide and .01 per cent. phosphoric acid and, whilst some losses did occur among the female arrows, they were not unduly large and the average solution cross produced as many viable seeds as comparable crosses made in the field at the same time. The use of solution crosses allowed the transfer of the crossing work from Freshwater to the Experiment Station and a consequent increase in the number of crosses which could be handled. At the present time practically all crosses are made in solution, the odd exception being made in the field when an important female which does not keep well in solution produces only a few arrows.

The contamination of one cross by the pollen from an adjacent one may be prevented by an adequate spacing of the crosses, but this considerably increases the area needed and some other method had to be developed. The crossing lanterns used at various stations overseas were not suitable for Queensland conditions and a special type measuring 3 feet x 3 feet x 6 feet was evolved. These are made of cotton voile on a wooden frame and, when mounted on battens on wooden scaffolding in a position sheltered from boisterous winds, allow a large number of solution crosses to be made in a comparatively small space.

The chief source of arrows for the crossing in 1937 was the planting at Freshwater, but over the succeeding years the plantings made at Meringa became the more important. The majority of varieties arrow quite satisfactorily at Meringa and an extensive crossing programme can be carried out using arrows



**Mr. HENRY TRYON, Entomologist, Department of Agriculture, who led the expedition to New Guinea in 1896 and brought back Badila.**



**Crossing lanterns at Meringa Experiment Station.**

from the Station alone. However, observations have shown that plantings at Freshwater consistently produce more arrows than those at Meringa, and that they emerge at an earlier date. At the present time the Freshwater plot is much smaller than the Meringa plantings and in general includes only shy arrowers or canes which have a very brief arrowing period. At Meringa more than 300 varieties are in cultivation. The maintenance of such a nursery of canes of widely divergent growth habits needs constant attention; the weak ratooners, for instance, have to be replanted every year, while certain wild canes have to be watched lest they take charge and crowd out the less hardy commercial varieties.

One of the difficulties frequently met with in making crosses between different canes is that the arrowing periods do not overlap. Experiments to force canes to arrow have not been successful and while the differential arrowing as between Freshwater and Meringa mentioned above was often of assistance, the most useful results were obtained by the lopping of the leaves during the summer months. Such a practice could be applied only to freely arrowing varieties but it definitely delayed the arrowing or spread it over a longer period.

Further results of the work in the years following 1937 were the synthesizing of a large number of parents and the use of a much wider range of parents than before. The cold-resistant *spontaneum* strain from Turkmenistan was incorporated in a number of crosses and the extensive testing of seedlings with various dilutions is still under way. Some overseas varieties containing various other strains of *S. spontaneum* proved very valuable as parents. Among these may be mentioned Co.281, Co.290 and some of the higher number P.O.J. varieties such as P.O.J.2725 and P.O.J. 2878. *Saccharum robustum* yielded promising seedlings when diluted with noble lines, and is still under test, for it transmits several characteristics such as hard rind, erectness and vigour, which are necessary in Queensland varieties. The *S. barberi* group did not prove very satisfactory.

It was agreed that sowing the fuzz as soon as it was ready in late June, July or August led to an undesirable late planting of the seedlings in the field, which did not coincide with the commercial planting dates. The planting of seedlings in October-November meant that very immature canes were being

**Crossing lanterns in use at Meringa. Note long skirts to prevent ingress of stray pollen.**



selected in the following winter. The most practical method of overcoming this obstacle was to store the fuzz from one season to the following year. Experiments showed that fuzz stored very well if dried, then packed in air-tight tins containing a small amount of calcium chloride, and kept at a temperature below 40°F. The stored fuzz retains its germinating capacity and can be sown during the summer. Seedlings are then put out into the field by early winter and thus enjoy a growing period somewhat comparable with commercial plantings. Fuzz from exploratory crosses or those particularly desired can, of course, be still sown soon after ripening and put out into the field that year.

The methods of selection in the seedlings received considerable attention during the ten years under review and at present a workable scheme has been evolved. It is in no sense final and will no doubt be modified considerably at several points with further experience. The selection amongst the original seedlings is made on the basis of 1/40 acre plots within each one of which the seedlings are compared with each other and

**Another view of the drying racks after crossing.**

with the stools of a standard cane which are planted at short intervals in lines across the drills. The concept of a selection within such a small plot eliminates the effect of soil variations in different parts of the field and also ensures that all seedlings are not taken from the portion of the field showing

**A battery of crossing lanterns in use during the cross pollination season. Note the light forest vegetation to minimise wind currents.**

**These arrows are starting to "fluff off" and are ready for picking.**

the best growth. Selection is usually made on the ratoons at Meringa and it is considered that if possible seedlings at all Stations should be selected at that stage. The percentage of seedlings selected for further propagation is usually less than two per cent. but the indications at present are that it would be advisable to increase this, even if it meant a reduction in the number of original seedlings grown.

Some interesting information on a statistical basis has been obtained with regard to the selection of the original seedlings. Comparisons of figures for stooling and brix in these seedlings with those obtained when the seedlings are planted out into the 40-sett plot stage, show that selectors should not attach much importance to difference between original seedlings unless they are considerable. Analysis showed for instance that a difference of three sticks between plant original seedling individuals—that is, a difference of the order of 25 to 35 per cent.—has to be disregarded when making the selections. Indications were that an even larger difference was necessary in ratoon seedlings. Differences in hand refractometer average brixes of samples taken by trier from the growing stalks similarly have to be disregarded unless they are greater than two units in plant seedlings; ratoon figures have to exceed three units.

**Looking upwards into a crossing lantern.**

The first propagation planting of a 4 x 10-sett plot allows observations on agricultural habits but it is impossible at this stage, owing to the variability which occurs between stools in the one clone, to attach significance to differences in yield between the various seedlings or between seedlings and the plots of the standard cane. Selection is from plant 40-sett plots and some significance is attached to the figures for sugar obtained from this planting. All seedlings taken in the 40-sett plot selection are planted in yield observation trials, followed after growth in plant and first ratoons by a planting of the advanced seedlings in some form of replicated trial. These are propagated on commercial farms away from the Experiment Stations either before or after the results have been obtained from the replicated Station trials and are then ready for assessment as commercial varieties, providing the reactions to the diseases against which they have been tested have proved satisfactory.

Although a great deal of time during the last few years has been devoted to the long-range programme of building up synthesized parents and special blood lines, considerable success has already been achieved in the production of commercial varieties. They are designated "Q" canes and some figure very prominently in the varietal returns from



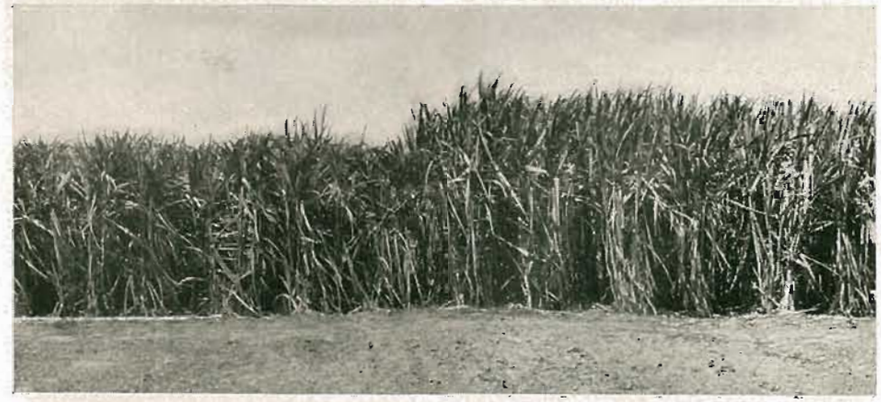
various districts. In the far north, Q.44 has yielded some excellent crops on second-class land and, providing it can be kept free from leaf-scald disease, should continue its role of a useful, although minor variety. Attempts to produce a cane which would perform as well as Badila on the better-class lands of the northern areas and be more resistant to diseases and pests have been

**The Bureau bred Q.50. This is already one of the major canes of the industry.**

unsuccessful although Badila itself has been tested as a parent in a wide range of crosses. "Q" varieties have not proved successful on the Burdekin, although as mentioned previously, an earlier Bureau seedling, S.J.16, is an important variety there. In the central districts about Mackay the "Q" varieties have had their greatest success to date. Q.28, which was bred in 1935, and went into farm trials in 1941, had by 1945 become the leading

**Q.49 was bred by the Bureau. This crop is 17 months old.**

cane in this region. Its excellent agricultural characteristics and ability to yield satisfactorily under adverse conditions made it more generally useful than any other variety. It yielded more than half the tonnage of the Mackay crop in 1947 and 1948, but at present is being eclipsed by the variety Q.50. At the moment it is difficult to prophesy which variety will ultimately prove of the most benefit to the district. Whichever one it is, there is no doubt that both varieties have yielded much heavier crops than the varieties such as E.K.28, M.1900S. and Co.290, which they have displaced. Q.50 came from fuzz sown in 1938 at Mackay Experiment Station and following the usual series of trials was first put on the approved list for the Mackay mills



**Q.45 on the right—a Bureau-bred seedling—easily outyields the standard commercial cane, Q.813.**

**S.J.16 was bred at South Johnstone Experiment Station. It is one of the major varieties in the Lower Burdekin.**

in 1947. More than 500,000 tons of this variety were harvested in 1949 and the 1950 yield is expected to be almost double this. Q.45 is another Bureau seedling bred at Mackay; it has been grown to some extent in the district.

**The Bureau bred Q.47 in the Bundaberg District.**

In South Queensland, despite the meteoric rise first of P.O.J.2878 and Co.290 and then of C.P.29/116, "Q" canes have at various times been important as minor varieties. Q.25 was the first of these and, although now largely displaced, in 1944 was the third most important cane in South Queensland and yielded more than 10 per cent. of the southern crop. Q.42 is an early maturing variety with a high c.c.s. but unfortunately its inability to ratoon under harsh conditions has prevented its use on a large scale. It shows considerable resistance to frost and is useful as a

**Q.44 was bred at Meringa Sugar Experiment Station.**

special-purpose cane. Q.47, another product of the Bundaberg Sugar Experiment Station, is showing promise as a one-year cropper with good c.c.s. Its reaction to disease is satisfactory and it is increasing in popularity. In 1949, 52,000 tons were crushed. The variety Q.49 is more disease resistant than P.O.J.2878 but it would appear that the newer varieties such as C.P.29/116 and Q.47 may prove more profitable.



**An arrowed side shoot on an arrowed stalk of Co.515.**

It was recognized quite early in the seedling work at the Experiment Stations that a variety which proved successful on a Station might not be so when tried in another part of the same district. This was overcome to some extent by propagating advanced seedlings in commercial plantings before any decision as to their future was made, but it was thought that the selection for a particular soil type or for a locality climate should be made from a number of original seedlings grown on the spot. Accordingly, in 1946, plantings of original seedlings were made at Babinda in the very wet tropical area. In the following year plantings were made at Mackay on a rich alluvial soil quite different from that at the Station but representative of a particular class of cane-producing land. In the south, seedlings from the Bundaberg Experiment Station are transferred to a plot at Beerwah for replanting and subsequent selection in the wet Moreton district. The reason for making the movement of seedlings through an isolation plot is that downy mildew occurs at Bundaberg and not in the Moreton district.

In 1947 J. H. Buzacott was appointed Senior Plant Breeder in charge of the crossing work at Meringa and the seedling selection activities at the other stations and sub-stations. His assistants include the officers in charge of the four Stations: G. Bates at Meringa, G. A. Christie at Ayr, C. G. Story at Mackay, and H. G. Knust at Bundaberg. In addition all Bureau field men assist in the

**Q.42 is an early-maturing Queensland bred variety.**

**Irrigating young cane seedlings at Bundaberg Experiment Station.**

selection work on the stations and in the conduct of varietal trials on commercial cane farms.

The recent work has proceeded on the lines laid down in the previous decade although at present there is a fresh emphasis on early maturity. It is unfortunate that there is apparently a high correlation between early maturity and great dilution or absence of wild blood. However, there are indications that some satisfactory early maturing canes may be produced in the near future from either the *spontaneum* line from Turkmenistan or such lines as those from Co.281 or Q.42.



# The Work of the Division of Mill Technology.

By J. L. CLAYTON.

**Mr. J. L. CLAYTON, Senior Mill Technologist.**

The Division of Mill Technology may be regarded as the maturing offspring of the Bureau organization, for on this Jubilee occasion the Mill Technology Division may claim merely to have attained its majority. Actually the first steps towards the establishment of the Division were taken in 1924 when N. Bennett was selected by the Queensland Government to undergo a period of training in sugar technology in overseas countries. Bennett returned to Queensland in 1928 which marks the commencement of the operation of the Division.

The technical standards of the industry at that time left much to be desired. From the chemical point of view there was a glaring lack of standardisation of both equipment and methods. In the manufacturing processes the mills operated for the most part as individual units, dependent for advancement upon their own initiative, and decidedly secretive as to any features of equipment or method which were considered to display some superiority. Bennett's early efforts were directed mainly towards encouraging co-operation between the mills and co-ordination of methods. He urged the standardisation of laboratory equipment and procedure, uniformity of chemical control data and the interchange of results between mills. Two very significant contributions to this policy were made in 1929. In that year the Bureau convened a meeting in Mackay at which the decision was made to constitute the Queensland Society of Sugar Cane Technologists. This organization did not enjoy immediate popularity and was regarded with considerable suspicion in some quarters. However, thanks to the solid support of its foundation members and the inherent worth of the Society it soon became firmly established in the industry.

The other important event of 1929 was the inauguration of the Mutual Control Scheme—a scheme providing for the interchange of factory operating data between mills and based on practices in several overseas countries. By 1930 the scheme was operated on a fortnightly basis, a practice which was maintained until activities were temporarily abandoned during the war.

The Mutual Control Scheme has since been revived and now circulates figures on a weekly basis. The number of mills contributing has increased to 26.

The first work of an experimental nature was commenced in 1930 following the appointment of E. R. Behne to the staff, and the establishment of a laboratory at Mackay. In addition to considerable work on the standardisation of glassware, weights and instruments, Behne investigated many features of mill operations and made a special study of the manufacture of power alcohol from B molasses.

The resignation of Bennett in 1932 represented a severe setback to the Division in this early stage of its development. The centre of activities was transferred to Brisbane and the sole technologist continued his investigations under conditions which must have been very trying.

The compilation of the Laboratory Manual for Queensland Sugar Mills was commenced in 1933, the first edition being published in the following year. The volume was well received and adopted as the standard work of reference as to analytical procedure in the industry.

No action was taken to increase the staff of the Division until 1934 when D. L. McBryde was appointed Assistant Mill Technologist. In the following year he was transferred to the field staff and N. Smith was appointed in his stead. The year 1935 also saw the appointment of Ir. J. Eigenhuis as Engineer Technologist, and the commencement of a period of intense activity and fairly rapid expansion. Under the direction of Eigenhuis investigations were conducted into practically every section of mill operations, the Technical Communications were inaugurated and slack season research projects undertaken. Smith resigned in 1937 and was replaced by G. H. Jenkins. In 1938 Eigenhuis returned to Java and A. H. Praeger and J. L. Clayton joined the staff. Investigations were continued both in the mills and in the laboratory. The second edition of the Laboratory Manual was published in 1939 and Technical Communications were issued frequently during this period. When it began

**Part of milling plant at Mourilyan Sugar Mill.**

**Ir. J. EIGENHUIS, Engineer—Technologist, 1935-1938.**

to appear that the Technology Division might at last have achieved some reasonable degree of strength and stability the outbreak of war disrupted the organization. First. in 1941, Jenkins resigned, and then in 1942 Praeger and Clayton were made available to the Commonwealth Government for service in the flax industry. Once again, as in 1932, Behne found himself the sole technologist member of the Mill Technology staff.

Investigations into sugar manufacture lapsed completely until 1945 when Clayton returned from the south and J. H. Nicklin was appointed Technologist Engineer. The further appointments of C. B. Venton, in 1946, and L. R. Brain and B. G. Adkins, in 1947, served to build up the staff to record numbers.

Since the war the Division of Mill Technology has undoubtedly occupied a more prominent position in Bureau affairs than previously. The visit of Behne to Cuba, U.S.A. and Hawaii in 1945 represented the realization of an ambition long cherished by the Division; later, in 1948, when Behne resigned, Clayton took charge of the mill operations staff and in that year visited the territory of Hawaii.



Recently three further officers, A. D. Doolan, K. Yore and A. G. Claire, have been added to the staff, which now comprises no less than nine. As might be expected, in view of this rapid expansion, the majority of the officers lack experience, but all are equipped with the necessary technical background and possess great potentialities.

It is of interest to review the most obvious contributions which the Technology Division has made to sugar manufacture in Queensland.

### THE QUEENSLAND SOCIETY OF SUGAR CANE TECHNOLOGISTS.

This Society has enjoyed the full support of the Division since its inception and throughout the years a major portion of the organization of the Society's activities, particularly in regard to the publication of the Proceedings, has been undertaken by the Bureau. All the findings of the Division which were of current local interest have been communicated to the industry through the Proceedings of the Society. Whilst the Queensland Society of Sugar Cane Technologists is a completely independent body it has served as an excellent liaison between the Bureau and the industry.

### THE WORK OF NORMAN SMITH.

Though he served only a brief period with the Bureau, Smith's investigations yielded results of outstanding importance. It is not generally known that Smith practised and recommended fractional liming during clarification tests in 1936, and, whilst there is no certainty that this discovery was made prior to that of Davies, it was, at least, quite independent. Later fractional liming proved to be of immense benefit to the industry.

Smith also studied sugar boiling, particularly in relation to vacuum pan design. His examination of the construction and performance of coil pans led to the evolution of design standards which subsequent experience has completely vindicated. Recently developed types of coil pan differ substantially from any encountered by Smith, but his criteria of performance are still applicable and reliable.

Behne subsequently conducted a parallel survey of calandria pans including one of the Webre type. Although his work yielded significant results the natural circulation calandria pan has not proved popular in Queensland, and it was actually many years before the Webre type enjoyed widespread favour.

### SUGAR BOILING METHODS.

During the years up to about 1934 sugar boiling in Queensland was a mysterious art surrounded by secrecy and revealed only to those who had served a long apprenticeship in the work.

When the refiners commenced a campaign for improvement in sugar quality the Bureau appointed D. L. McBryde to specialise in the subject. Later he visited many mills instructing in the use of the microscope for pan work and in the regulation of boiling by conductivity. Other investigators in the industry took up the subject and by 1938 a new standard of boiling technique was established. The Bureau constantly advocated the adoption of the three massecuite system and within a few years this became the accepted practice at all but one or two mills.

Quite recently the boiling of final massecuites has been made the subject of exhaustive study and already it is clear that there is a growing realization of the benefits to be derived from an organized study of the problem. There is still room for a more scientific approach to sugar boiling in the industry, but the changes which have been brought about in the past fifteen years are quite spectacular.

### THE SUGAR BUREAU pH METER.

The venture initiated by Eigenhuis into the design of a meter for the continuous measurement of pH under factory conditions was truly a pioneering effort. Admittedly instruments had already been proposed for this purpose, and Dr. Khainovsky, in Java, had developed a

Part of pan stage—Tully Sugar Mill.

meter, but this was battery operated. Eigenhuis set out to design a cheap simple mains-operated pH meter suitable for continuous use in the factory—and was anxious to extend the work to provide for the automatic control of pH if possible. The work was commenced in 1936 and successive models of pH meter were produced until 1939, when the enterprise was handed over to the firm which had co-operated in the work practically from the beginning.

The Sugar Bureau pH meter is now something of a back number, for continuous operating pH meters are commonplace these days. Nevertheless, in its day, the Bureau meter was a leader in the field, and it is noteworthy that the principles incorporated in its design are easily recognizable in most of the more modern units which have since been developed.

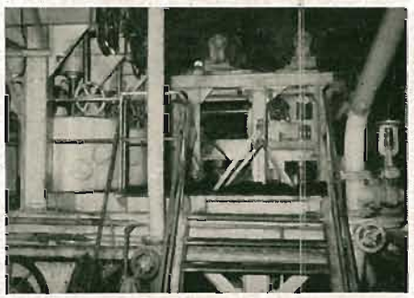
## GENERAL.

The above items are only a few of those which could be advanced. Since 1937, which really marks the beginning of organized investigations, the following aspects of mill operations have been studied: Preparation of cane, milling, maceration, boiler operation, clarification, filtration, sugar boiling, crystallization, fugalling, sugar conditioning, steam economy and sampling and analytical procedure.

Further important investigations were undertaken in the Bureau laboratories during the slack seasons from about 1936 onwards. A scheme was inaugurated whereby chemists attached to various mill companies performed the work under the direction of the Bureau staff. Naturally, the field of research during the slack season is restricted, but at various times bagasse, sugar and molasses have been studied. The ultimate analysis of bagasse and its calorific value, the physical properties of raw sugar and molasses and the conductometric determination of ash were among the subjects selected.

The results of all major projects have been published in the form of Technical Communications; briefer or less important findings have been recorded in papers submitted to the Technologists' Society; whilst notes of general interest have been incorporated in the News Letter, a periodical published by the Bureau for local distribution.

Apart from research work the Division has rendered considerable service to the mills by way of investigations into particular local problems and reports on mill operations. Of recent years the officers of the Division have frequently been called into consultation in plans for major alteration or extension in various factories. Regular services include the testing of all types of volumetric glassware as well as brix hydrometers, polariscopes, polariscope tubes and weights. Scientific instruments of various types are overhauled and calibrated; indicators, buffers and colorimetric pH standards are issued regularly, and in general by way of advice or assistance every effort has been made to supply the requirements of the mills.



The low-grade fugal station at Farleigh Mill.



New 6,000-gallon Webre Pan at Farleigh Mill.

## FACTORY WORK.

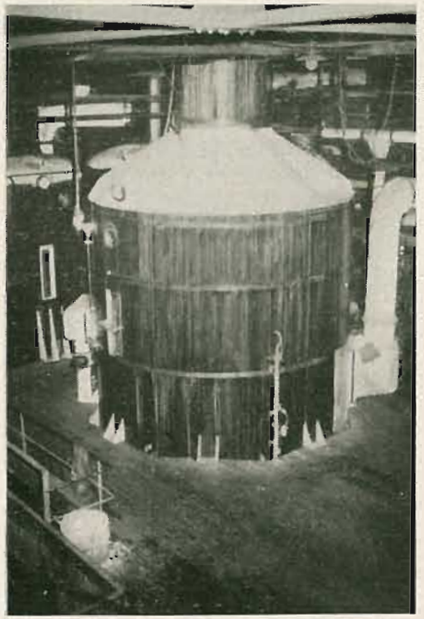
In any attempt to analyse the performances of the Queensland factories since the formation of the Division of Mill Technology one is confronted with the results of the influence of a multitude of uncontrollable factors, and it is now quite apparent that the effects of these variables overshadow any increases in technical efficiency which may be attributable directly to research. Besides the part played by these factors, the industry in Queensland has suffered considerably from external influences, and it is exceedingly difficult to estimate real improvements in the operating standards of the factories.

In Fig. 1 are illustrated the changes in production which have taken place in the last 21 years. Although the production figures for 1948 and 1949 were considerably higher than any previously recorded, it will be seen that the lowest yield for the period occurred in 1943, when the amounts of cane and sugar produced were almost half the quantities for 1948 and 1949. Under such conditions it is difficult to maintain high standards of performance.

Of course, in normal times, the most important single factor influencing the work of the factory is the quality of the cane to be crushed, and obviously this is affected by conditions which cannot be controlled. However, in the period under review the factories have been adversely affected, in addition, by practices consequent upon wartime conditions. The influence of these factors is immediately evident from a perusal of the graphs in Figs. 2 and 3 where the values of various criteria of performance have been plotted. In Fig. 2, the quality of the cane has been represented by the purity of the first expressed juice.

It will be seen that except for comparatively minor variations, the purity of the first expressed juice remained reasonably constant at about 89.6 per cent. until 1945. In subsequent seasons the purity has been abnormally low, particularly in 1946, when a large portion of the cane-growing districts suffered a severe drought. It is apparent that until 1941 there was a general upward trend in the pol recovery which provides a clear indication of improved efficiency of operation. It is seen from Fig. 2 that when appreciable changes occur in the purity of the first expressed juice the pol recovery varied in the same direction. Similarly the amount of molasses produced per ton of cane is directly related to the quality of the cane crushed.

The values for the co-efficient of work varied rather spectacularly prior to 1941 and the reasons for some of these are not clear. However, the general decline in the co-efficient of work from 1934 to 1938 coincided with a particularly large increase in the crushing rate. The year 1939 marked the first signs of the general improvement in factory work which resulted from the extensive programme of research commenced about 1937. At this time the processes involved in milling, clarification, sugar boiling and fugalling were closely studied, and concurrently several new types of equipment were introduced into the Queensland factories.



No. 1 effet vessel at Inkerman Mill—10,000 sq. ft. H.S.

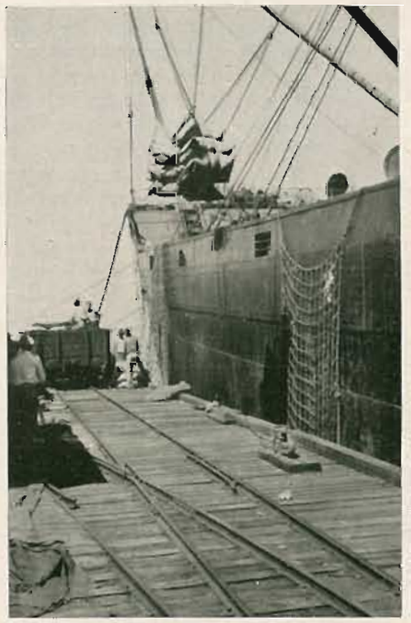
before production reached the 1941 level. Very poor seasons in 1946 and 1947, due mainly to drought conditions, were responsible for the worst performance figures of the period.

Although production has now returned to normal standards, the factory efficiency has not responded so quickly. In the first place, owing to the inability of mills to pursue the normal programme of replacement of obsolete equipment during the war, a rush to order new plant occurred immediately afterwards and long delay between the placing of an order and the delivery of the plant has resulted. The position was aggravated seriously by the introduction of the 40-hour week, and the necessity for still higher rates has made efficiency a secondary consideration. Apart from this, there are several features of the post-war economy which have militated against improved performance. Most of these are associated with casual practices adopted in the field during the war. Thus, now most of the cane is delivered

However, without a doubt, the most significant improvement occurred in the boiling house following the investigation into both the boiling process and the design of the vacuum pans. The three massecuite system was gradually being accepted by the industry also, with the result that conditions were being made easier on the pan stage.

The improvement in all phases of the boiling house was undoubtedly responsible for the sharp rise in co-efficient of work. At the same time it was found possible to increase the crushing rate and maintain the standard of work.

In 1942 the full impact of wartime conditions was felt by the industry. For this and the following three seasons, the uncertain labour position, the enforced restriction on crushing rate and the necessity, in many mills, for two-shift operations caused a severe slump in factory efficiency. Although circumstances were becoming more favourable by 1945, the industry was destined to wait until 1948



Loading sugar at Bowen wharf.



burnt instead of green as it was previously; carelessness in harvesting has resulted in a sharp increase in the amount of extraneous matter; and often long delays occur between the burning of the cane and its delivery to the mill.

It is considered that although the performance figures for the last two seasons are not outstanding, in most cases the actual factory work has been of a high standard, and the mills have done very well to compete with past performances under much less favourable circumstances.

At the present time important changes are taking place in the industry and many new types of equipment are being installed. Once again probably the most important advances made in factory equipment have been in the boiling house and fugal stations. Almost all factories have installed or have taken delivery of high-speed fugals for the treatment of final massecuites. In addition the use of Webre pans and pans of the flattened coil type has led to considerable improvement in the boiling of C massecuite. In the design of coil pans Queensland undoubtedly leads most other countries.

Power alcohol distillery at Sarina.

Social and economic conditions in Queensland at present make it justifiable to sacrifice efficiency in favour of throughput, and this state of affairs is likely to continue for at least another three years.

By 1953 the mills should have completed the major portion of the expansion programme now proceeding and it should then be possible to demonstrate properly the technical advances which have been made since the Division of Mill Technology commenced its work.

## CHRONOLOGY.

1889. Mackay nursery established at the Lagoons.
First cane seedlings produced in Queensland.

1892. Turner surveyed insect pests damaging sugar cane in Queensland.

1895. Serious outbreak of gumming disease in South Queensland.

1896. Badila brought from New Guinea. Tryon suggested carbon bisulphide soil fumigation for grub control.

1898. Laboratory added to nursery.

1899. Dr. Maxwell arrived from Hawaii to report on the Queensland Sugar Industry.

1900. Assent to "*The Sugar Experiment Stations Act of* 1900."
Appointment of Dr. W. Maxwell as first Director.

1901. Laboratory and administrative building opened at Bundaberg.

1909. Dr. Maxwell resigned. E. G. Scriven appointed Director.

1910. H. T. Easterby, Assistant Director, resigned to go to Maffra beet sugar factory. Dr. A. J. Gibson appointed General Superintendent. Tachinid fly parasite of cane beetle borer established by Moir at Mossman.

1911. Start of entomological division; A. A. Girault came from America and was stationed at Nelson (now Gordonvale.)

1912. Dr. Gibson resigned and Easterby returned as General Superintendent.

1913. Bundaberg Sugar Experiment Station established.

1914. E. Jarvis appointed Entomologist.

1917. Dr. J. F. Illingworth, Entomologist, arrived from Hawaii.
South Johnstone station established.

1920. Fresh build-up of gumming disease.

1921. Seedling raising commenced at South Johnstone. H. T. Easterby appointed Director.

1924. Travelling Research Scholars selected. A. F. Bell, N. Bennett and H. W. Kerr proceeded overseas. First disease survey of cane areas made by W. Cotrell-Dormer.

1925. Entomological laboratory attached to Bundaberg Sugar Experiment Station.

1926. Fiji disease first recorded.

1928. Research Scholars returned to Australia and were appointed to the staff of the Bureau. Constitution of Division of Pathology—importation of selected canes. Entomological laboratory attached to Mackay Sugar Experiment Station.

1929. Reorganization of Bureau. Divisions of Soils and Agriculture, Entomology, Pathology and Mill Technology instituted. Mill Technology Laboratory equipped at Mackay. First meeting called to form Queensland Society of Sugar Cane Technologists. Messrs. Easterby and Bennett represented the Bureau at the I.S.S.C.T. Congress in Java. Widespread losses from gumming in South Queensland—chlorotic streak first recorded; quarantine districts proclaimed.

1930. N. J. King began reconnaissance soil survey of sugar producing areas. Beginning of seedling raising on Bundaberg and Mackay stations. Planting of breeding canes at Freshwater. Dwarf disease first recorded; variety garden established.

1931. Cane breeding sub-station established at Freshwater. Brisbane pathology plot acquired.

1932. Death of H. T. Easterby. Dr. H. W. Kerr appointed Director. Transfer of Mill Technology laboratory to Brisbane. Bureau represented by A. F. Bell at I.S.S.C.T. Congress at Puerto Rico. E. J. Barke visited Java to study cane breeding technique.

1933. Transmission of Fiji disease by cane leafhopper established by Mungomery and Bell. Establishment of Sugar Experiment Stations Advisory Board.

1928-33. First disease resistance trials instituted.

1934. Northern Sugar Experiment Station moved from South Johnstone to Meringa. Approved variety lists issued; pathology and entomology amalgamated into one division.

1935. R. W. Mungomery visited Hawaii and arranged importation of *Bufo marinus* colony. Ir. J. Eigenhuis appointed as Engineer Technologist. First Conference of Cane Pest and Disease Control Boards. New Mackay Station established at Te Kowai. Quarantine house at Brisbane in use for first time.

1938. Bureau represented by N. J. King at I.S.S.C.T. Congress in Louisiana. Ir. J. Eigenhuis returned to Java. Amendment to *Sugar Experiment Stations Acts.*

1945. Dr. H. W. Kerr resigned and A. F. Bell appointed as Director. First trials with "Gammexane" against greyback grubs. First record of ratoon stunting disease; gumming found at Mossman, only record in Queensland.

1946. Babinda sub-station first planted with seedlings.

1947. E. R. Behne appointed Director. Mackay sub-station first planted with seedlings.

1948. N. J. King appointed Director. Acquirement of property for new Experiment Station in Lower Burdekin area. Seven thousand acres successfully treated with "Gammexane" for grub control and 3,000 acres against wireworm attack.

1949. Control of pineapple disease by dipping established as farm practice; small amount downy mildew at Hambledon and Bundaberg only records for the State; Disease resistance trial sub-station established at Moggill. Twenty thousand acres successfully treated with benzene hexachloride for grub control and almost fifteen thousand acres protected against wireworm attack.



# List of Technical Publications Issued by the Bureau of Sugar Experiment Stations.

## TECHNICAL COMMUNICATIONS.

### MILL TECHNOLOGY.

1937.

1936 Seasonal Investigations on Hot and Cold Liming, by N. Smith.

Circulation in Coil Vacuum Pans, by N. Smith.

Boiler and Furnace Testing in a Cane Sugar Mill, by J. Eigenhuis.

The Analysis and Sampling of Final Bagasse, by E. R. Behne.

Milling Tests, by E. R. Behne.

Furnace Investigations, by J. Eigenhuis.

The Sugar Bureau pH Meter, by E. R. Behne and J. Eigenhuis.

The Ultimate Analysis of Bagasse, by F. H. C. Kelly.

The Combustion Value of Bagasse, by R. W. G. Hessey.

Preliminary Investigation into the Fugalling of Final Massecuites, by E. Mitchell and E. R. Behne

1938.

(i.) Furnace Investigations, 1937, and

(ii.) Revision of some Stoickiometric Formulae of Technical Communication No. 5, 1937, by G. H. Jenkins.

Continuous Electrometric pH Control, by J. Eigenhuis.

Circulation in Calandria Vacuum Pans, by E. R. Behne.

Milling Tests, 1937 Season, by G. H. Jenkins.

The Analysis and Sampling of Final Bagasse, by G. H. Jenkins.

Clarification Tests, 1937 Season, by E. R. Behne and G. H. Jenkins.

Volume and Surface Relationships of Raw Sugar, by L. Drinnen.

The Separation of Molasses from the Sugar Crystals in the Fugals, by E. R. Behne.

1939.

Clarification Tests, 1938 Season, by E. R. Behne.

Automatic Liming Control, by E. R. Behne.

The Fugalling Process and High Speed Centrifugals, by E. R. Behne.

Subsider Performance Tests, 1938 Season, by G. H. Jenkins.

Furnace Investigations, 1938 Season, by G. H. Jenkins.

Surplus Power from Surplus Bagasse, by G. H. Jenkins.

Massecuite Dilution Tests, by G. H. Jenkins.

Some Physical Properties of Molasses, by A. H. Praeger and J. L. Heron.

1940.

Cane Preparation, Part 1—The National Shredder, by E. R. Behne.

Rotary Filters for Treatment of Cane Muds, by G. H. Jenkins.

Automatic pH Control, by J. L. Clayton.

Furnace Investigations, 1939 Season, by G. H. Jenkins.

The Hygroscopicity of Raw Sugar, by J. H. Webster.

The Conductometric Determination of Ash, by E. D. Jensen.

Tests on the Dorr Clarifier, by G. H. Jenkins.

Glossary of Terms Used in Queensland Sugar Cane Factories, compiled by the Technology Division.

1941.

Cane Preparation, Part II., by E. R. Behne.

Crystallization of Raw Sugar in Factory Practice, by G. H. Jenkins.

The Clarification Process, by E. R. Behne.

### SOILS AND AGRICULTURE.

1937.

Irrigation Waters of the Burdekin Delta, by N. G. Cassidy.

The Determiuation of Fibre in Cane, by H. W. Kerr and N. G. Cassidy.

1938.

The Laboratory Determination of Soil Fertility, by H. W. Kerr and C. R. von Stieglitz.

Some Studies in Soil Sampling Technique, by H. W. Kerr and C. R. von Stieglitz.

The Determination of Fibre in Cane II., by H. W. Kerr.

1939.

Basic Lead Acetate—Its Composition and Clarifying Qualities, by C. R. von Stieglitz.

Field Experimentation with Sugar Cane, by H. W. Kerr.

Alternate Hosts of *B. Vasculorum*, by C. G. Hughes.

1941.

Downy Mildew Disease of Cane and Other Grasses, by C. W. Leece.

Legume Inoculation in Queensland Canefields, by D. R. L. Steindl.

1949.

The Production and Testing of Sugar Cane Seedlings, by C. G. Hughes.

Irrigation Waters of the Bundaberg Area, by N. J. King.

1950.

Soils Investigations in the Sugar Cane Producing Areas of Bundaberg, by N. J. King.

Control of the ''Greyback'' Cane Grub Pest (*Dermolepida albohirtum* Waterh) by means of ''Gammexane'' (Benzene Hexachloride), by R. W. Mungomery.

## CONTRIBUTIONS TO THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE.

1944.

An Investigation of the Rat Pest Problem in Queensland Canefields. 1, Economic Aspects, by W. A. McDougall.

An Investigation of the Rat Pest Problem in Queensland Canefields. 2, Species and General Habits, by W. A. McDougall.

An Investigation of the Rat Pest Problem in Queensland Canefields. 3, Laboratory Experiments on Food Intake and Toxicity, by W. A. McDougall.

1946.

An Investigation of the Rat Pest Problem in Queensland Canefields. 4, Breeding and Life Histories, by W. A. McDougall.

An Investigation of the Rat Pest Problem in Queensland Canefields. 5, Populations, by W. A. McDougall.

An Investigation of the Rat Pest Problem in Queensland Canefields. 6, Controls and Conclusions, by W. A. McDougall.

1947.

Investigations in the Control of Wireworms (*Lacon variabilis* Caud.) in Canefields with ''Gammexane,'' by W. A. McDougall.

1949.

The Rat Poisons Sodium Fluoroacetate and ''Castrix,'' by W. A. McDougall.

## BULLETINS.

### GENERAL SERIES.

No. 1, 1913. The Cultivation of Cane Upon Old Lands, by H. T. Easterby.

No. 2, 1915. Varieties of Sugar Cane in Queensland, by H. T. Easterby.

No. 3, 1924. The Cultivation of Sugar Cane in Queensland, by H. T. Easterby.

No. 4, 1924. Summary of Some Experiments Conducted with Sugar Cane and of Soil and Other Chemical Analyses from 1902 to 1923, by H. T. Easterby and G. R. Patten.

No. 5, 1928. Sugar Cane Growing in Queensland—some economic phases.

### FARM SERIES.

No. 1, 1931. Farm Fertility Trials—1930 Season, by H. W. Kerr.

No. 2, 1931. Cane Culture, Disease and Pest Control, by H. W. Kerr, A. F. Bell and R. W. Mungomery.

No. 3, 1932. Farm Fertility Trials—1931 Season, by H. W. Kerr.

No. 4, 1932. The Childers Cane Beetle, by R. W. Mungomery.

No. 5, 1932. Soils in their Relationship to Sugar Cane Culture, by H. W. Kerr.

No. 6, 1933. Value of Different Forms of Lime, by H. W. Kerr and C. R. von Stieglitz.

Intensive Cane Production, by H. W. Kerr and E. J. Barke.



No. 7, 1933. Farm Fertility Trials—1932 Season, by H. W. Kerr.

No. 8, Dwarf Disease of Sugar Cane, by A. F. Bell.

No. 9, The Greyback Cane Beetle and its Control, by E. Jarvis.

No. 10, 1949. Green Manuring and Soil Organic Matter, by N. J. King.

No. 11, 1950. The Treatment of Cane Setts with Mercurial Solutions, by C. G. Hughes.

### PATHOLOGY SERIES.

No. 1, Top Rot of the Sugar Cane, by H. Tryon.

No. 2, A Key for the Field Identification of Sugar Cane Diseases, by A. F. Bell.

No. 3, (i.) Dwarf Disease of Sugar Cane by A. F. Bell.
(ii.) The Cane Killing Weed, by A. F. Bell and W. Cottrell-Dormer.
(iii.) Red Stripe Disease of Sugar Cane in Queensland, by W. Cottrell-Dormer.

No. 4, Fiji Disease of Sugar Cane and its Transmission, by R. W. Mungomery and A. F. Bell.

### ENTOMOLOGY SERIES.

No. 1, 1914. The White Grubs of Sugar Cane in Queensland, by A. A. Girault.

No. 2, 1915. The Cane Grubs of Australia, by A. A. Girault and A. P. Dodd.

No. 3, 1916. Notes on Insects Damaging Sugar Cane in Queensland, by E. Jarvis.

No. 4, 1916. On the Value of Poison Bait for Controlling Cane Grubs, by E. Jarvis.

No. 5, 1917. Notes on the Habits and Metamorphosis of Lepidiota frenchi, Black., by E. Jarvis.

No. 6, 1917. The Cane Grubs of Australia, Part II., by A. P. Dodd.

No. 7, 1917-18. Monthly Notes on Grubs and Other Cane Pests, by J. F. Illingworth.

No. 8, 1918-19. Monthly Notes on Grubs and Other Cane Pests, by J. F. Illingworth.

No. 9, 1920. Some Lepidopterous Pests New to Sugar Cane in Queensland, by E. Jarvis.

No. 10, 1919-20. Monthly Notes on Grubs and Other Cane Pests, by J. F. Illingworth.

No. 11, 1921. An Account of a New Moth Borer of Sugar Cane (Family Tineidae); together with Further Notes on the Pyralid Moth Borer of Cane (Polyocha sp.), by E. Jarvis.

No. 12, 1921. A Study of Natural Methods of Control for White Grubs, by J. F. Illingworth.

No. 13, 1921. Natural Enemies of Sugar Cane Beetles in Queensland, by J. F. Illingworth.

No. 14, 1921. The Linear Bug, Phaenacantha australica Kirkaldy: A New Pest of Sugar Cane in Queensland, by J. F. Illingworth.

No. 15, 1920-21. Monthly Notes on Grubs and Other Cane Pests, by J. F. Illingworth.

No. 16, 1921. Australian Sugar Cane Beetles and Their Allies, by J. F. Illingworth and A. P. Dodd.

No. 17, 1923. Notes on Queensland Cane Insects and Their Control, by E. Jarvis.

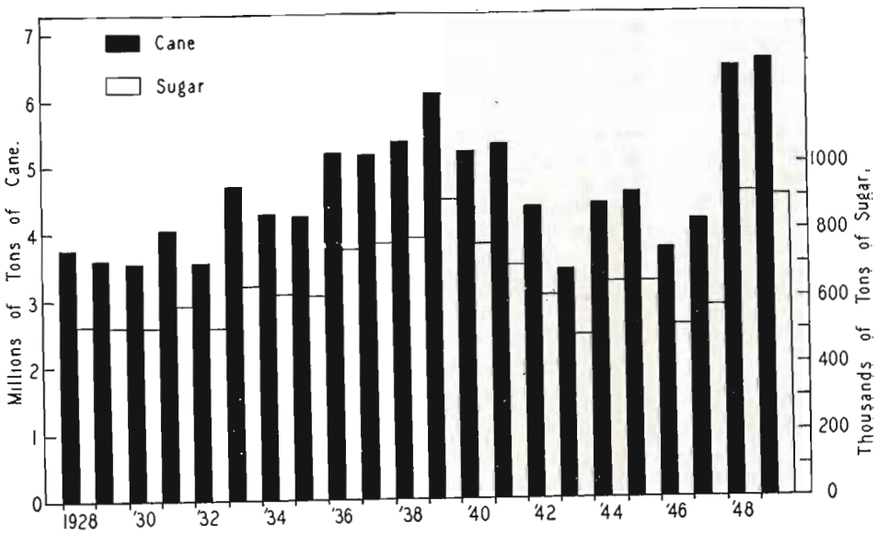
No. 18, 1925. Notes on Queensland Cane Insects and Their Control, by E. Jarvis.

No. 19, 1926. Notes on Queensland Cane Insects and Their Control, by E. Jarvis.

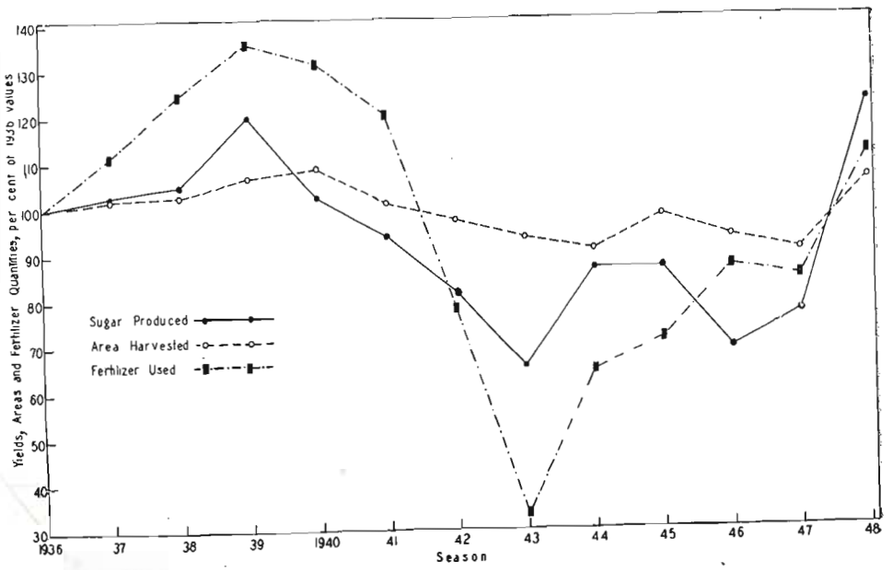
No. 20, 1929. Some Notes on the Economy of Cockchafer Beetles, by E. Jarvis.

No. 21, The Determination of Larval Instars and Stadia of Some Wireworms (Elateridae), by W. A. McDougall.

No. 22, The Wireworm Pest and Its Control in Central Queensland Sugar Cane Fields, by W. A. McDougall.

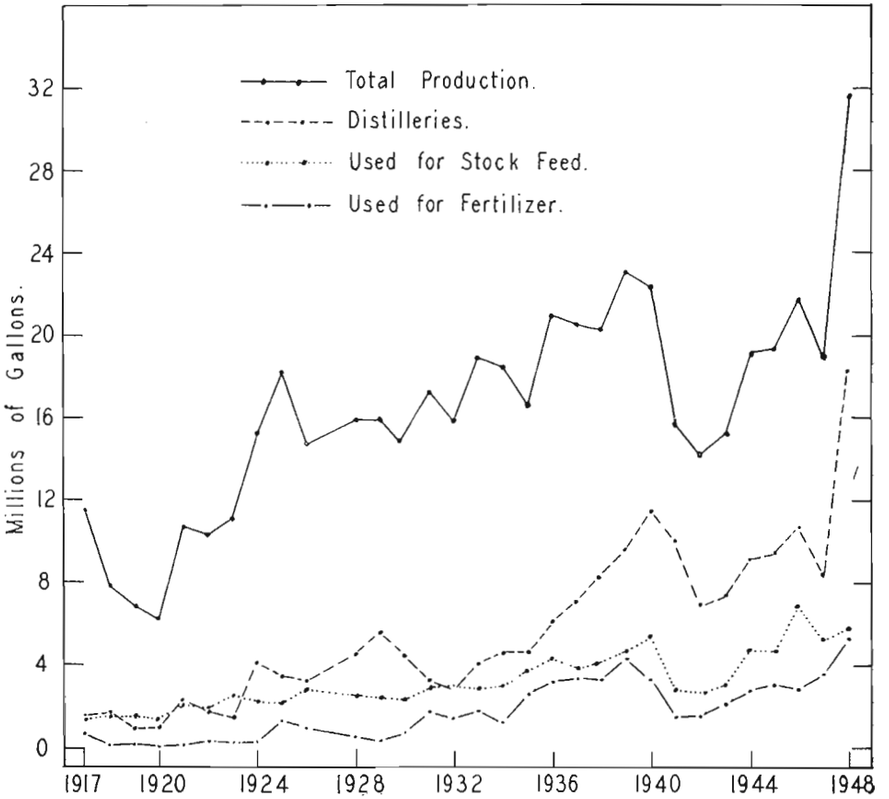



**Cane and sugar production in Queensland for 22 years. The full effect of wartime shortages of labour, fertilizer and machinery was felt in 1943.**

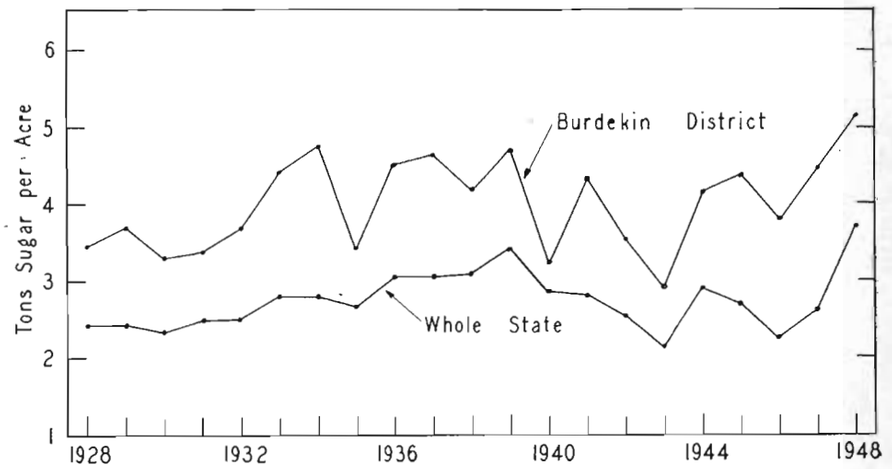



**Although the acreage harvested did not fall appreciably in the war years the effect of fertilizer shortage on production was to almost halve the crop.**

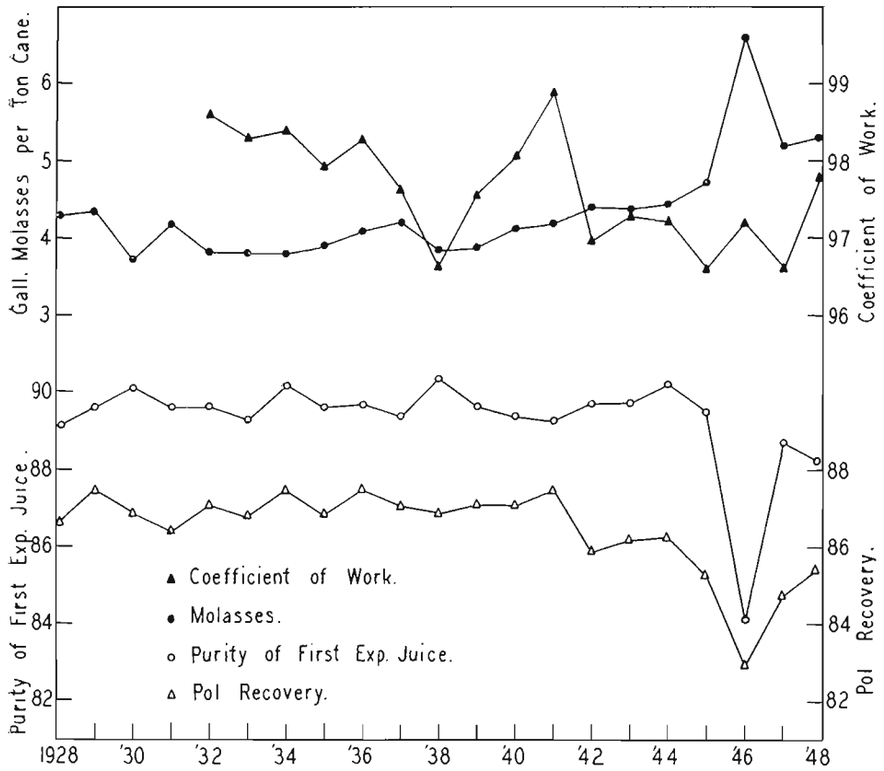




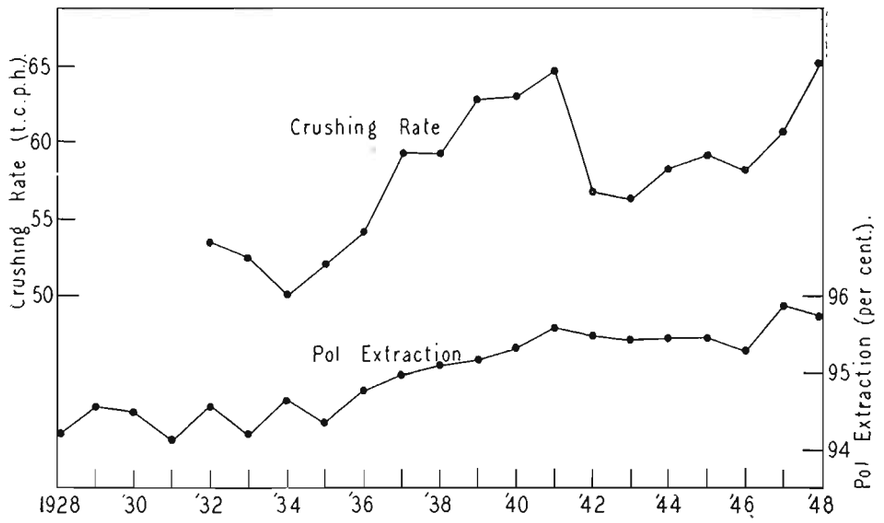

**Illustrating the principal avenues of usage of molasses.**




**Contrasting sugar per acre production in the irrigated Burdekin district with that of the whole State.**

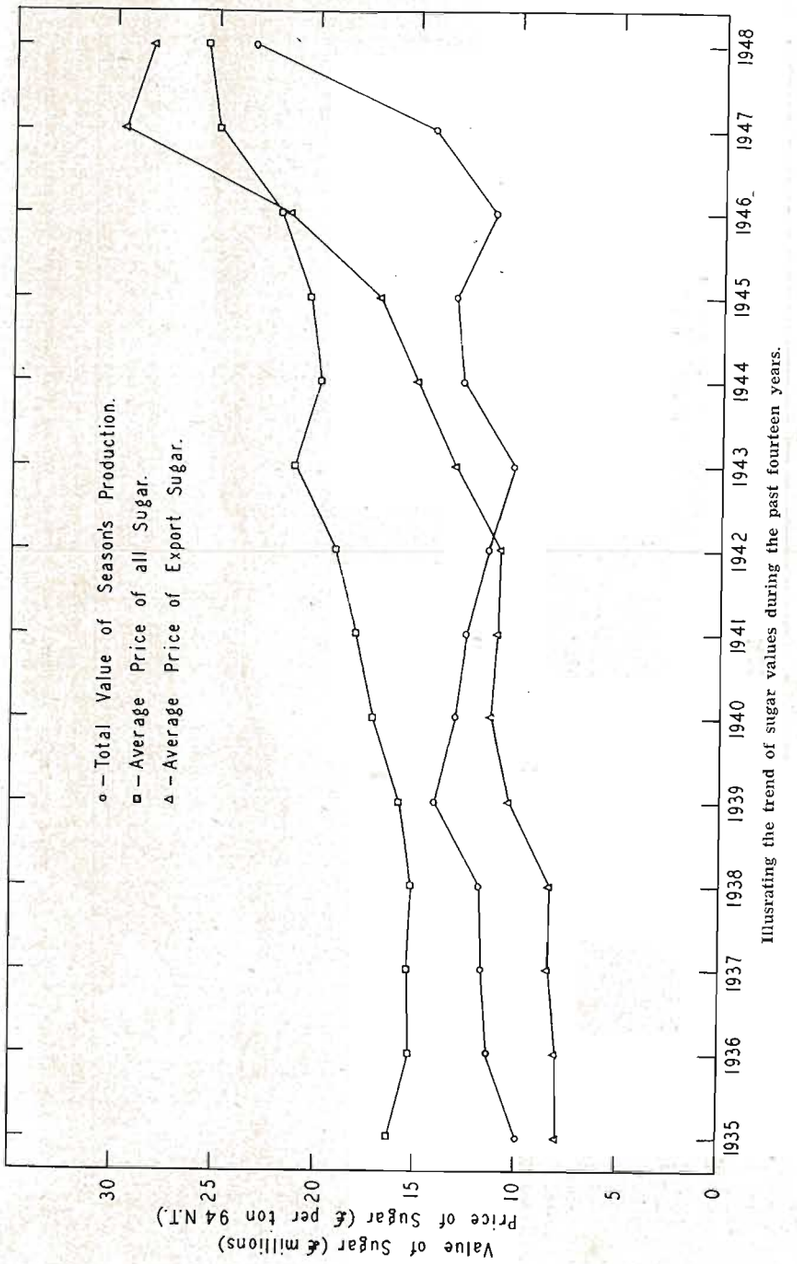



**Curves illustrating trends in various key figures for 24 Queensland factories.**

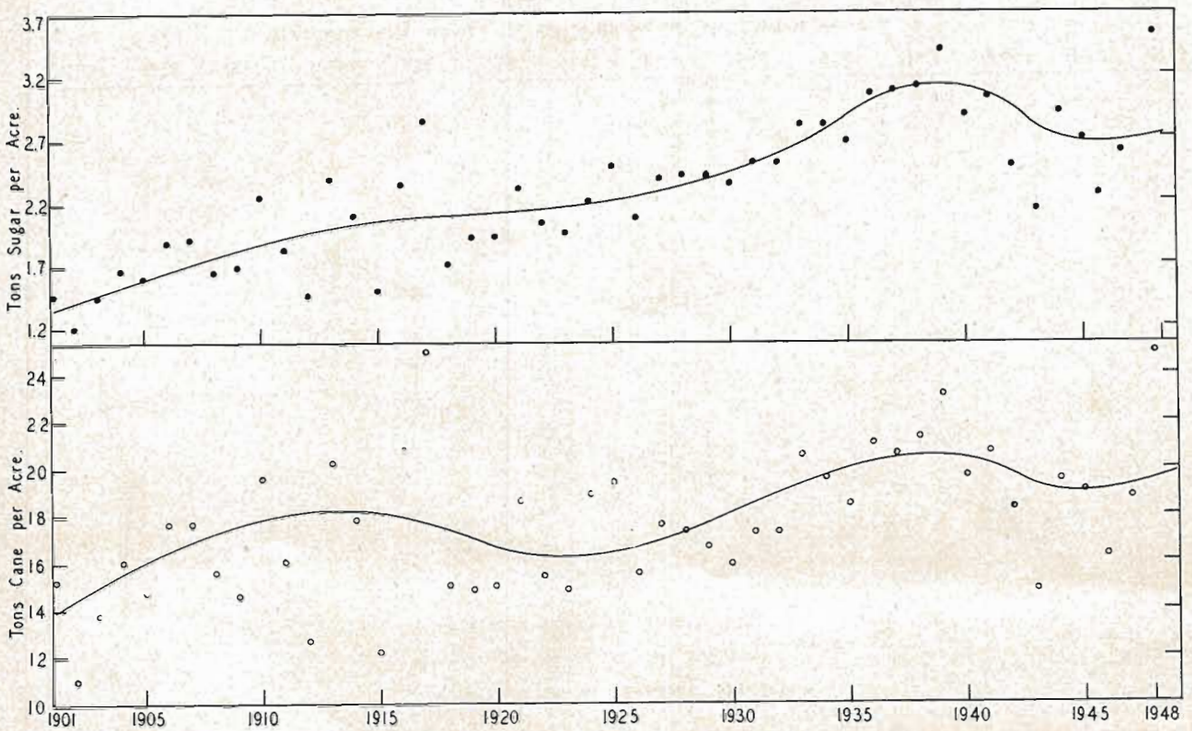



**Crushing Rate and Pol Extraction curves for 24 Queensland factories.**






**Illustrating the trend of sugar values during the past fourteen years.**




**The improvement in cane and sugar production per acre over 48 years. During that period sugar per acre has increased from 1.45 to 3.52 tons per acre.**

TABLE OF SUGAR PRODUCTION AND CONSUMPTION IN AUSTRALIA AND EXPORTABLE SURPLUS.

| Year. | * Production (94 n.t.). | | | Consumption (94 n.t.). | | | Export (94 n.t.) by Difference. | | |
|---|---|---|---|---|---|---|---|---|---|
| | In Queensland. | In N.S.W. | Total. | From Queensland Crop. | From N.S.W. Crop. | Total. | From Queensland Crop. | From N.S.W. Crop. | Total. |
| 1935 .. .. | 610,307 | 36,453 | 646,760 | 313,376 | 23,165 | 336,541 | 296,931 | 13,288 | 310,219 |
| 1936 .. .. | 744,261 | 38,151 | 782,412 | 335,741 | 23,596 | 359,337 | 408,520 | 14,555 | 423,075 |
| 1937 .. .. | 762,794 | 47,058 | 809,852 | 341,121 | 23,796 | 364,917 | 421,673 | 23,262 | 444,935 |
| 1938 .. .. | 776,810 | 45,095 | 821,905 | 339,426 | 24,035 | 363,461 | 437,384 | 21,060 | 458,444 |
| 1939 .. .. | 891,218 | 36,929 | 928,147 | 360,185 | 23,292 | 383,477 | 531,033 | 13,637 | 544,670 |
| 1940 .. .. | 758,966 | 47,031 | 805,997 | 375,267 | 24,224 | 399,491 | 383,699 | 22,807 | 406,506 |
| 1941 .. .. | 696,927 | 48,322 | 745,249 | 415,652 | 25,276 | 440,928 | 281,275 | 23,046 | 304,321 |
| 1942 .. .. | 605,361 | 44,281 | 649,642 | 417,281 | 24,983 | 442,264 | 188,080 | 19,298 | 207,378 |
| 1943 .. .. | 486,354 | 37,440 | 523,794 | 410,704 | 23,424 | 434,128 | 75,650 | 14,016 | 89,666 |
| 1944 .. .. | 643,475 | 26,423 | 669,898 | 434,796 | 19,438 | 454,234 | 208,679 | 6,985 | 215,664 |
| 1945 .. .. | 644,624 | 21,220 | 665,844 | 439,171 | 16,717 | 455,888 | 205,453 | 4,503 | 209,956 |
| 1946 .. .. | 512,035 | 39,768 | 551,803 | 439,457 | 23,953 | 463,410 | 72,578 | 15,815 | 88,393 |
| 1947 .. .. | 571,503 | 33,551 | 605,054 | 476,257 | 22,294 | 498,551 | 95,246 | 11,257 | 106,503 |
| 1948 .. .. | 909,896 | 32,998 | 942,894 | 469,081 | 30,740 | 499,821 | 440,815 | 2,258 | 443,073 |

* Does not include Local Sale.

*Local Sales in Queensland.*

| | |
|---|---|
| 1935 .. .. .. .. | 19 |
| 1936 .. .. .. .. | 387 |
| 1937 .. .. .. .. | 531 |
| 1938 .. .. .. .. | 1,326 |
| 1939 .. .. .. .. | 526 |
| 1940 .. .. .. .. | 605 |
| 1941 .. .. .. .. | 530 |
| 1942 .. .. .. .. | 319 |
| 1943 .. .. .. .. | 93 |
| 1944 .. .. .. .. | 65 |
| 1945 .. .. .. .. | 37 |
| 1946 .. .. .. .. | 51 |
| 1947 .. .. .. .. | 191 |
| 1948 .. .. .. .. | 153 |

*Beet Sugar Produced at Maffra.**

| | |
|---|---|
| 1935 .. .. .. .. | 4,580 |
| 1936 .. .. .. .. | 5,115 |
| 1937 .. .. .. .. | 4,180 |
| 1938 .. .. .. .. | 5,625 |
| 1939 .. .. .. .. | 1,507 |
| 1940 .. .. .. .. | 6,280 |
| 1941 .. .. .. .. | 3,279 |
| 1942 .. .. .. .. | 2,754 |
| 1943 .. .. .. .. | 663 |
| 1944 .. .. .. .. | 689 |
| 1945 .. .. .. .. | Nil |
| 1946 .. .. .. .. | Nil |
| 1947 .. .. .. .. | 1,014 |
| 1948 .. .. .. .. | 583 |

* This is consumed in Australia.

TABLE SHOWING FROM 1910 TO 1948 THE NUMBER OF MILLS NORTH AND SOUTH OF TOWNSVILLE AND THE SUGAR PRODUCED.

| Year. | District. | No. of Mills. | Sugar Produced 94 n.t. |
|---|---|---|---|
| | | | Tons. |
| 1910 .. | North of Townsville .. .. .. .. .. | 7 | 57,135 |
| | South of Townsville .. .. .. .. .. | 42 | 153,621 |
| 1916 .. | North of Townsville .. .. .. .. .. | 9 | 98,396 |
| | South of Townsville .. .. .. .. .. | 38 | 78,577 |
| 1922 .. | North of Townsville .. .. .. .. .. | 9 | 120,617 |
| | South of Townsville .. .. .. .. .. | 31 | 167,618 |
| 1928 .. | North of Townsville .. .. .. .. .. | 10 | 255,188 |
| | South of Townsville .. .. .. .. .. | 25 | 265,432 |
| 1934 .. | North of Townsville .. .. .. .. .. | 10 | 233,457 |
| | South of Townsville .. .. .. .. .. | 23 | 379,113 |
| 1940 .. | North of Townsville .. .. .. .. .. | 10 | 309,437 |
| | South of Townsville .. .. .. .. .. | 23 | 450,009 |
| 1946 .. | North of Townsville .. .. .. .. .. | 10 | 233,732 |
| | South of Townsville .. .. .. .. .. | 22 | 278,354 |
| 1947 .. | North of Townsville .. .. .. .. .. | 10 | 255,958 |
| | South of Townsville .. .. .. .. .. | 22 | 315,700 |
| 1948 .. | North of Townsville .. .. .. .. .. | 10 | 356,969 |
| | South of Townsville .. .. .. .. .. | 22 | 553,080 |

TABLE SHOWING INDUSTRY INCOME AND EXPENDITURE ON BUREAU RESEARCH SINCE 1926.

| Year. | Expenditure.* | Industry Income. | Percentage of Industry Income Devoted to Bureau Research. |
|---|---|---|---|
| | £ s. d. | £ | |
| 1926–27 .. .. .. .. .. | 18,628 11 8 | 11,289,600 | 0·16 |
| 1927–28 .. .. .. .. .. | 17,953 12 10 | 11,210,100 | 0·16 |
| 1928–29 .. .. .. .. .. | 23,531 3 0 | 11,894,300 | 0·22 |
| 1929–30 .. .. .. .. .. | 25,494 12 7 | 12,331,000 | 0·20 |
| 1930–31 .. .. .. .. .. | 23,465 9 6 | 12,035,500 | 0·20 |
| 1931–32 .. .. .. .. .. | 16,074 2 0 | 11,496,000 | 0·14 |
| 1932–33 .. .. .. .. .. | 14,418 3 3 | 10,080,000 | 0·14 |
| 1933–34 .. .. .. .. .. | 18,603 13 5 | 10,328,700 | 0·18 |
| 1934–35 .. .. .. .. .. | 20,636 8 10 | 9,488,000 | 0·22 |
| 1935–36 .. .. .. .. .. | 25,033 16 11 | 9,873,000 | 0·26 |
| 1936–37 .. .. .. .. .. | 25,056 6 9 | 11,337,600 | 0·22 |
| 1937–38 .. .. .. .. .. | 24,260 2 9 | 11,686,600 | 0·21 |
| 1938–39 .. .. .. .. .. | 25,642 9 11 | 11,738,000 | 0·22 |
| 1939–40 .. .. .. .. .. | 25,673 3 2 | 14,046,500 | 0·18 |
| 1940–41 .. .. .. .. .. | 23,976 1 1 | 13,003,600 | 0·18 |
| 1941–42 .. .. .. .. .. | 20,270 13 11 | 12,550,500 | 0·16 |
| 1942–43 .. .. .. .. .. | 16,080 11 5 | 11,516,000 | 0·14 |
| 1943–44 .. .. .. .. .. | 16,133 16 7 | 10,244,000 | 0·16 |
| 1944–45 .. .. .. .. .. | 19,069 4 8 | 12,744,000 | 0·15 |
| 1945–46 .. .. .. .. .. | 27,476 0 7 | 13,087,000 | 0·21 |
| 1946–47 .. .. .. .. .. | 30,751 3 9 | 11,184,000 | 0·27 |
| 1947–48 .. .. .. .. .. | 39,351 0 11 | 14,251,000 | 0·28 |
| 1948–49 .. .. .. .. .. | 45,721 19 4 | 23,198,000 | 0·20 |

* Prior to the Act of 1934 the Treasury endowed the assessment £ for £: subsequent to that year the Government contribution was limited to £7,000. These amounts should therefore be deducted from those shown above to arrive at industry expenditure. The percentage of income shown includes the Government contribution.



TABLE OF PRODUCTION OF CANE AND SUGAR PER ACRE FOR EACH YEAR AND FOR FIVE YEAR PERIODS, 1900–1949.

| Year. | Acres Harvested. | Tons Cane Per Acre. | Tons Sugar Per Acre. 94 n.t. | Five Year Averages. | | |
|---|---|---|---|---|---|---|
| | | | | Acres Harvested. | Tons Cane Per Acre. | Tons Sugar Per Acre. |
| 1900 .. .. .. | 72,651 | 11·68 | 1·19 | | | |
| 1901 .. .. .. | 78,160 | 15·10 | 1·45 | | | |
| 1902 .. .. .. | 59,102 | 10·56 | 1·21 | 70,606 | 13·49 | 1·39 |
| 1903 .. .. .. | 60,375 | 13·65 | 1·42 | | | |
| 1904 .. .. .. | 82,741 | 16·04 | 1·67 | | | |
| 1905 .. .. .. | 96,093 | 14·73 | 1·59 | | | |
| 1906 .. .. .. | 98,194 | 17·61 | 1·88 | | | |
| 1907 .. .. .. | 94,384 | 17·64 | 2·00 | 92,197 | 16·01 | 1·76 |
| 1908 .. .. .. | 92,219 | 15·54 | 1·64 | | | |
| 1909 .. .. .. | 80,095 | 14·53 | 1·68 | | | |
| 1910 .. .. .. | 94,641 | 19·45 | 2·23 | | | |
| 1911 .. .. .. | 95,766 | 16·02 | 1·81 | | | |
| 1912 .. .. .. | 78,142 | 12·72 | 1·45 | 95,873 | 17·26 | 2·00 |
| 1913 .. .. .. | 102,803 | 20·29 | 2·36 | | | |
| 1914 .. .. .. | 108,013 | 17·80 | 2·09 | | | |
| 1915 .. .. .. | 94,459 | 12·20 | 1·49 | | | |
| 1916 .. .. .. | 75,914 | 20·81 | 2·33 | | | |
| 1917 .. .. .. | 108,707 | 24·88 | 2·83 | 95,106 | 17·55 | 2·05 |
| 1918 .. .. .. | 111,572 | 15·01 | 1·70 | | | |
| 1919 .. .. .. | 84,877 | 14·83 | 1·91 | | | |
| 1920 .. .. .. | 89,142 | 15·03 | 1·88 | | | |
| 1921 .. .. .. | 122,956 | 18·60 | 2·30 | | | |
| 1922 .. .. .. | 140,850 | 15·39 | 2·04 | 131,868 | 16·54 | 2·12 |
| 1923 .. .. .. | 138,742 | 14·75 | 1·94 | | | |
| 1924 .. .. .. | 167,649 | 18·92 | 2·44 | | | |
| 1925 .. .. .. | 189,466 | 19·36 | 2·56 | | | |
| 1926 .. .. .. | 189,312 | 15·45 | 2·06 | | | |
| 1927 .. .. .. | 203,748 | 17·45 | 2·38 | 202,618 | 17·25 | 2·36 |
| 1928 .. .. .. | 215,674 | 17·32 | 2·41 | | | |
| 1929 .. .. .. | 214,880 | 16·67 | 2·41 | | | |
| 1930 .. .. .. | 222,044 | 15·89 | 2·33 | | | |
| 1931 .. .. .. | 233,304 | 17·29 | 2·49 | | | |
| 1932 .. .. .. | 205,046 | 17·30 | 2·51 | 221,395 | 18·10 | 2·59 |
| 1933 .. .. .. | 228,154 | 20·46 | 2·80 | | | |
| 1934 .. .. .. | 218,426 | 19·56 | 2·80 | | | |
| 1935 .. .. .. | 228,515 | 18·47 | 2·67 | | | |
| 1936 .. .. .. | 245,152 | 21·10 | 3·04 | | | |
| 1937 .. .. .. | 249,683 | 20·56 | 3·06 | 247,092 | 20·91 | 3·06 |
| 1938 .. .. .. | 251,064 | 21·28 | 3·10 | | | |
| 1939 .. .. .. | 261,047 | 23·14 | 3·41 | | | |
| 1940 .. .. .. | 265,738 | 19·50 | 2·86 | | | |
| 1941 .. .. .. | 246,939 | 19·41 | 2·82 | | | |
| 1942 .. .. .. | 238,213 | 18·26 | 2·54 | 240,400 | 18·36 | 2·65 |
| 1943 .. .. .. | 228,895 | 14·84 | 2·13 | | | |
| 1944 .. .. .. | 222,215 | 19·79 | 2·90 | | | |
| 1945 .. .. .. | 239,826 | 18·98 | 2·69 | | | |
| 1946 .. .. .. | 228,395 | 16·26 | 2·24 | | | |
| 1947 .. .. .. | 220,649 | 18·81 | 2·59 | 244,554 | 20·53 | 2·86 |
| 1948 .. .. .. | 258,585 | 24·88 | 3·52 | | | |
| 1949 .. .. .. | 275,313 | 23·70 | 3·25 | | | |

TABLE OF MILL PEAKS AND OF PROPOSED ULTIMATE PEAK BY 1953.

| Mill. | 1929. | 1939. | 1949. | 1950.† | Proposed Ultimate 1953 Peak. |
|---|---|---|---|---|---|
| Mossman | 14,972 | 20,000 | 22,000 | 22,000 | 27,000 |
| Hambledon | 31,836 | 36,000 | 39,600 | 39,600 | 44,000 |
| Mulgrave | 31,643 | 36,000 | 40,100 | 40,100 | 44,000 |
| Babinda | 31,901 | 36,000 | 39,600 | 39,600 | 45,000 |
| Goondi | 27,034 | 29,500 | 32,400 | 32,400 | 37,000 |
| South Johnstone | 30,979 | 35,000 | 39,600 | 39,600 | 47,000 |
| Mourilyan | 23,630 | 27,000 | 29,700 | 29,700 | 32,000 |
| Tully | 30,930 | 38,000 | 42,100 | 42,100 | 47,000 |
| Macknade | 30,952 | 34,000 | 39,900 | 46,500 | 49,000 |
| Victoria | 32,221 | 37,500 | 43,600 | 49,100 | 82,000 |
| Invicta | 11,736 | 16,000 | 18,300 | 19,100 | 27,000 |
| Kalamia | 26,053 | 31,000 | 35,400 | 35,600 | 40,000 |
| Pioneer | 21,391 | 26,000 | 30,100 | 34,000 | 36,100 |
| Inkerman | *24,207 | 31,000 | 36,800 | 42,000 | 46,800 |
| Proserpine | 16,650 | 23,000 | 26,300 | 33,000 | 36,500 |
| Farleigh | 16,993 | 23,000 | 27,600 | 32,400 | 34,800 |
| Racecourse | 18,066 | 24,000 | 29,000 | 35,200 | 36,700 |
| Pleystowe | 19,781 | 24,000 | 29,200 | 35,900 | 37,900 |
| Marian | 18,997 | 24,000 | 28,600 | 32,300 | 34,400 |
| North Eton | 9,319 | 12,000 | 14,500 | 15,900 | 17,600 |
| Cattle Creek | 8,791 | 12,000 | 13,400 | 14,100 | 15,200 |
| Plane Creek | 18,233 | 24,000 | 28,600 | 30,800 | 34,100 |
| Fairymead | 15,882 | 21,000 | 25,700 | 28,600 | 30,200 |
| Qunaba | 8,940 | 10,000 | 11,200 | 12,700 | 13,700 |
| Millaquin | 14,443 | 19,000 | 24,100 | 29,600 | 31,800 |
| Bingera | 17,864 | 23,000 | 27,800 | 31,000 | 33,400 |
| Gin Gin | 6,000 | 6,500 | 8,000 | 8,400 | 11,000 |
| Isis | 28,011 | 27,000 | 30,000 | 30,200 | 31,600 |
| Maryborough | 3,862 | 7,500 | 9,500 | 9,500 | 12,000 |
| Mount Bauple | 6,231 | 6,500 | 7,200 | 7,200 | 8,000 |
| Moreton | 11,586 | 14,000 | 16,000 | 16,000 | 19,000 |
| Eagleby | 280 | 300 | .. | .. | .. |
| Rocky Point | 2,014 | 2,200 | 2,700 | 2,700 | 3,200 |
| | 611,428 | 737,000 | 848,600 | 916,900 | 1,045,000 |

* Increased by 2,500 tons in 1938.
† Does not include 3 per cent. for Soldiers' Settlement.

A. H. TUCKER, Government Printer, Brisbane.