DIGEST OF THE PROCEEDINGS

OF THE

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OF THE

International Society of Sugar Cane Technologists

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SOME OF THE REPRESENTATIVES AT THE FIRST INTERNATIONAL SUGAR CONFERENCE

Sitting, left to right: Mario Calvino, of Cuba; Hamilton P. Agee, Hawaii; W. R. McAllep, Hawaii; D. S. North, Australia; Y. Kutsunai, Hawaii; C. E. Pemberton, Hawaii; Guy R. Stewart, Hawaii; R. L. Pendleton, India and the Philippines.

Standing, left to right: Jared Smith, Hawaii; Twigg Smith, Hawaii; Ralph Wood, Cuba; J. A. Verret, Hawaii; P. J. S. Cramer, Java; J. W. Waldron, Hawaii; Wm. van H. Duker, Hawaii; F. D. Fromme, Continental United States; Kintaro Oshima, Formosa; Herbert Osborn, Cont. U. S.; M. S. Barnett, Australia; H. Atherton Lee, Hawaii and Philippines; Migaku Ishida, Formosa; J. P. Martin, Hawaii; O. H. Swezey, Hawaii; Hunter Freeman, Australia; T. D. A. Cockerell, Cont. U. S.; H. L. Lyon, Hawaii; Fred Hanson, Hawaii; E. W. Brandes, Cont. U. S.; Harry F. Clarke, Fiji; W. P. Alexander, Hawaii; John A. Scott, Hawaii; J. S. Rosa, Hawaii.

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HONOLULU, AUGUST, 1924

An International Conference of Cane Sugar Men

Meeting as the sugar section of the First Pan-Pacific Food Conservation Conference, representatives from various parts of the cane sugar world held discussions on technical problems of common interest, July 28 to August 14, 1924.

There were thirteen sessions in all. The subjects which received attention are listed as follows, with the names of those presiding as leaders of the discussions:

July 29—Sugar Cane Breeding (continued August 5), E. W. Brandes.
July 30—Sugar Cane Quarantine, H. L. Lyon.
August 1—Methods of Cultivation, Hunter Freeman.
August 4—Varieties and the Jeswiet Identification System, Mario Calvino.
August 5—Cane Diseases, D. S. North.
August 6—Bud Selection, H. F. Clarke.
August 6—Cane Entomology, O. H. Swezey.
August 7—Soils and Fertilizers, Kintaro Oshima and G. R. Stewart.
August 8—Rodent Control, C. E. Pemberton.
August 11—Factory Engineering, Norman Kay.
August 11—Factory Operation and Control in Sugar Cane Factories, W. R. McAllep.
August 13—Irrigation, Wm. P. Alexander.

Those who participated in the discussions, listed by countries, were:

Australia—

M. S. Barnett, Head of Technical Field Section, Colonial Sugar Refining Company.
Hunter Freeman, Field Officer, Colonial Sugar Refining Company.
D. S. North, Plant Pathologist, Colonial Sugar Refining Company.

British West India—

British West India Committee represented by Mr. Robt. Catton of Honolulu.

Continental United States—

E. W. Brandes, Pathologist in Charge, Sugar Plant Investigations, U. S. D. A.
T. D. A. Cockerell, Professor of Zoology, University of Colorado.
C. L. Marlatt, Chairman, Federal Horticultural Board, U. S. D. A.
Herbert Osborn, Research Professor, Ohio State University.

Cuba—

Mario Calvino, Director, Experiment Station of Chaparra Sugar Company.
Ralph Wood, Manager, Chaparra Sugar Company.

Fiji—

Harry Flockton Clarke, In Charge Agri. Experiments, Colonial Sugar Refining Company.

Formosa—

Migaku Ishida, Chief of Sugar Exp. Sta., Government Research Institute.
Kintaro Oshima, Director, Dept. Agr., Government Research Institute.

India—

R. L. Pendleton, formerly of India, now with University of Philippines.

Mexico—

R. H. Van Zwaluwenburg, Entomologist, United Sugar Companies.

Philippine Islands—

H. Atherton Lee, formerly of the Philippines, now with H. S. P. A. Experiment Station.
R. L. Pendleton.

Porto Rico—

Norman Kay, Chief Engineer, Central Aguirre Sugar Company.

Hawaiian Islands, U. S. A.—

H. P. Agee
W. P. Alexander
J. D. Bond
W. van H. Duker
C. F. Eckart
W. G. Hall
R. H. Hughes
Horace Johnson
Ernest Kopke
Y. Kutsunai
H. Atherton Lee
H. L. Lyon
W. R. McAllep
W. L. McCleery
W. W. G. Moir
S. S. Peck
C. E. Pemberton
J. Lewis Renton
John A. Scott
Twigg Smith
Walter E. Smith
J. B. Steffee
G. R. Stewart
O. H. Swezey
J. A. Verret
J. W. Waldron
John M. Watt
F. X. Williams
J. N. S. Williams

Factory Operations (By W. R. McAllep)

On Monday, August 11, the program of the sugar section of the Pan-Pacific Food Conservation Conference was given over to discussing factory operations. In the morning Mr. Norman Kay, Chief Engineer of Central Aguirre, Porto Rico, led the discussion from an engineering standpoint. In the afternoon session technical considerations and chemical control were taken up with W. R. McAllep leading the discussion.

Mr. Kay gave an interesting talk on grooving with particular reference to handling returned settlings from the Petree process. The problem was solved by replacing the customary 60° grooving with grooving of 37½° angle and ½ inch pitch. The extraction was higher than before the Petree process was installed but moisture in bagasse was in excess of 50 per cent.

Mr. Ralph Wood, administrator of the Chaparra estate of the Cuban-American Company, spoke of milling under Cuban conditions. On account of an ample supply of cheap cane and a limited grinding season, extraction is considered secondary to capacity. Double crushers with 60° grooving, 3-inch pitch on the first and 1.5-inch pitch on the second, together with comparatively coarse grooving on the following units, have been found the best solution of this problem of passing a large tonnage of cane through the mill.

Mr. Barnett, of the Colonial Sugar Refining Company, spoke of milling practice in Fiji and Australia. The type of shredder known in Hawaii as the National is used in many mills. Extraction is obtained by a combination of milling and diffusion. In some factories long maceration baths, similar to those at McBryde Sugar Company are used. In other factories large annular drums containing revolving rakes are installed between the mills. In both cases the apparatus is kept partly filled with maceration water. The partly crushed cane averages about fifteen minutes in passing through them. The maceration baths are kept hot to prevent bacterial action and lime is added to reduce inversion.

Mr. Duker spoke on the importance of having Krajewski crusher rolls mesh properly.

Under the subject of milling practice in Hawaii, Mr. Hall spoke on the advantages of the Searby shredder.

Discussion centered largely on efforts during the last few years to improve mill sanitation, including replacing the old slat conveyors with the Ewart, Ramsey, and Meinecke types, the installation of juice pans with steep sides under the mills, the use of antiseptics around the mill and efforts to overcome the objectionable features and deficiencies of the conventional type of juice strainer, including returning the juices used as maceration without straining, the type of pump used for this purpose and the Peck strainer.

Mr. Kopke discussed centrifugal separation applied to handling settlings and other factory problems.

The afternoon session was opened by outlining the work of the Sugar Technology Department of the Experiment Station of the Hawaiian Sugar Planters' Association.

Under the subject of clarification, Dr. Ishida stated that 8 of the 45 factories in Formosa made white sugar for direct consumption, using the carbonatation process. Dr. Ishida also described the clarification process for use in direct consumption sugar manufacture developed by him at the Formosa Experiment Station. Ammonium and magnesium acetates are used. The increase in purity is as much as 7 or 8 points. The process has been tried out on a factory scale but is not yet used commercially. Filtration was one of the principal difficulties encountered.

The general discussion of clarification included the work in recent years at the Hawaiian Sugar Planters' Association, the Petree process and Dr. Horne's process. Under the discussion of the Petree process it was pointed out that while increases in extraction have been secured after installing it in cases where extraction is comparatively low, in Hawaii with high extractions a loss in extraction has followed its installation. The danger of inversion during the lengthened settling time was also pointed out. Favorable results in clarification were attributed more to the efficiency of the Dorr clarifier than to the process itself.

In the discussion of Dr. Horne's process, it was brought out that juices are first limed, heated and settled. Sodium phosphate is then added, replacing lime salts with the more soluble sodium salts, after which the juice is resettled. This has interesting possibilities in the way of reducing scale in evaporating apparatus and in reducing ash in the sugar. It is certain that most excellent clarification can be secured in any juices with this process.

During the discussion of refining qualities of sugar the fact was brought out that the Colonial Sugar Refining Company, which refines its own raws, produces sugars of 98.5 or higher polarization. The average polarization in Cuba was stated to be about 96.5.

Determining the amount of sugar entering the mill on the cane carrier was the principal subject discussed under Chemical Control. No satisfactory method has been developed for determining this directly. In Java, the Philippines, Formosa and Cuba it is calculated in approximately the same manner as in Hawaii; that is, sugar in bagasse is added to sugar in the mixed juice, and the sum accepted as the sugar in the cane, undetermined losses at the mill being disregarded. In Fiji and Australia sugar in the cane is calculated from the first expressed juice analysis using the following formula:

s = % sucrose in juice from front roller of first set;
f = % fibre in cane;

then,

$$\% \text{ sucrose in cane} = \frac{s \times (100 - (f + 5))}{100}$$

Efficiencies of different mills are compared on the basis of the ratio of a factor termed "Pure Obtainable Cane Sugar" to the sugar recovery in the bags. The factor "Pure Obtainable Cane Sugar" is calculated as follows:

s = (same as above)
f = (same as above)
S = % sucrose in cane (as above)
b = brix of juice from front roller of first set

then,

$$B = \text{Brix of cane} = \frac{b \times (100 - (f + 3))}{100}$$

and

$$\text{P. O. C. S. in Cane} = S - \tfrac{1}{2}(B - S)$$

In Cuba, boiling house efficiencies are calculated on the basis of Winter's formula. The quality ratio table formerly used in Hawaii is the reciprocal of the value obtained by this formula.

After a discussion of the difficulty in understanding manufacturing data reported from different countries and the desirability of having a uniform basis, the following resolution was adopted:

Be it Resolved, That in view of the difficulty in interpreting the figures obtained in the chemical control exercised in the sugar industry, it is desirable to adopt a uniform system of reporting data obtained in the manufacture of cane sugar, to the end that figures reported in one country may be understood in every other cane-producing region.

Sugar Cane Diseases (By H. Atherton Lee)

Root-rot was the opening subject of the discussion on cane diseases at which Mr. D. S. North, of Australia, presided.

The root-rot of Louisiana was described by Dr. E. W. Brandes of the U. S. Department of Agriculture, Washington, D. C. He stated that R. D. Rands, also of the Department of Agriculture, had found the cause of the root trouble in Louisiana. Dr. Brandes mentioned that he recently visited fields of some of the plantations here on Oahu, and, on Lahaina cane at Ewa Plantation, had found an organism similar to the causal organism of root-rot in Louisiana. A cable had just been received from Dr. K. F. Kellerman of the Department in Washington permitting the release of information, then in press, purporting to establish the cause of root-rot of sugar cane in Louisiana.

Dr. Brandes proceeded to say that in Louisiana small holes were found upon the roots, resulting in the root destruction, and that Mr. Rands had shown that a small mollusc or snail of the genus *Zonitoides* was responsible for these holes. A description of the holes was given.

Mr. Otto H. Swezey immediately brought out the point that investigators in Hawaii were familiar with these snail punctures, and he had mentioned four species of these molluscs in one of the publications of the Experiment Station, several years previously. He stated his view, however, that the work of the molluscs could not be considered responsible for what is called Lahaina disease here in Hawaii.

Mr. H. Atherton Lee pointed out that the injuries resulting from molluscs were not alone associated with root-rot of Lahaina cane; but that some of the healthiest Lahaina cane, as well as Yellow Caledonia, D 1135, and H 109 would often show attacks of the molluscs. Cane affected with these mollusc holes of the roots did not in many instances evidence any indication of Lahaina disease.

Dr. Harold Lyon brought out the same point and also stated that Mr. Cyril E. Pemberton had shown that in addition to the molluscs, a centipede would cause similar holes on cane roots. Mr. Pemberton mentioned the facts leading to the finding of the relationship between the holes and the centipedes. Many of the holes were smaller than those caused by molluscs and were too small to be accounted for in that way. A study of the problem had therefore been made, and centipedes definitely associated with these very small holes.

Returning to the question of the relationship between the molluscs and Lahaina disease it was brought out that the collection of these molluscs was made by Dr. Brandes from the field at Ewa in which Mr. W. T. McGeorge had shown the high salt concentration. Mr. McGeorge had subsequently shown rather clearly in culture studies that the Lahaina trouble in this field was due to this high salt concentration.

Under these circumstances the injuries resulting from the molluscs were apparently secondary, or at least a minor factor in causing the trouble. Mr. W. P. Alexander, of Ewa Plantation, described the area in which the molluscs had been found and corroborated the statements concerning the high salt concentration of the area.

Dr. Lyon pointed out that there were a number of root troubles; that Lahaina disease which was at one time considered to be due to a single cause had now resolved itself into at least three distinct troubles. He stated that the matter of the molluscs would no doubt be gone into thoroughly.

Mr. Guy R. Stewart related the methods of attack on Lahaina disease by the soil investigators. In several instances salt concentration had been shown by Mr. McGeorge to be high enough to be responsible for what was called Lahaina disease. In another district high acidity with a high concentration of soluble aluminum salts were held responsible for what had also been called Lahaina disease.

Two root diseases of cane were known in Formosa, according to Dr. Migaku Ishida, but he stated that not much progress had been made concerning their nature. In Australia, according to Mr. D. S. North, a root disease occurs which is one of their serious troubles. He related experiments in which they were able to transmit the root disease by butt cuttings. There are apparently several types of root troubles in Australia, according to Mr. North.

Mr. North then pointed out the need for knowledge of cane diseases in the various cane countries; with such knowledge, spread of such diseases to new countries could then be easily prevented. The more serious cane diseases of Australia were listed as follows: Gum disease caused by *Bacterium vascularum;* leaf scald caused by a bacterial organism not yet published upon; Fiji disease, the cause of which is unknown; mosaic disease, the cause of which is also unknown; downy mildew caused by a fungus, *Sclerospora sacchari;* red rot; various root rots; rust caused by the fungus *Puccinia kuehnii;* top rot; leaf sheath rots probably caused by *Rhizoctonia* and *Sclerotium* species; and knife cut.

Mr. North asked Mr. Lee to list the cane diseases of Hawaii and also of the Philippines.

The Hawaiian Islands were stated by Mr. Lee to be rather fortunate, in their comparative freedom from serious cane diseases. Although many planters in Hawaii felt that all cane diseases were present in Hawaii, compared with Australia, Java, India, Formosa or the Philippines this country is fairly free of cane diseases. The diseases here in order of the losses caused at the present time would probably be as follows: Mosaic disease, Lahaina disease, red stripe, eye-spot, Pahala blight, iliau, sectional chlorosis, ring spot, pineapple disease of standing cane and leaf freckle. Red rot has been recorded in Hawaii only once; a leaf spot caused by a fungus of the genus *Phyllosticta* was also observed once or twice. Of these diseases, mosaic disease causes little or no loss on most plantations, although on a few plantations attention is necessary to prevent material losses which are now occurring. The other diseases are causing very slight losses throughout the Territory at the present time.

In the Philippines, the following diseases are known: Fiji disease, leaf scald, cane smut, mosaic disease, downy mildew, eye spot, a flowering parasite somewhat similar to the mistletoe that lowers the quality of the cane juices enormously, ring spot, red rot, pineapple disease of cuttings and of standing canes, pokkah bong, sclerotial banded disease, a leaf spot caused by the fungus *Cercospora kopkei*, another spot caused by a fungus of the genus *Pestalozzia*, another leaf-spot caused by a fungus, *Phyllachora sacchari*, rust caused by the fungus *Puccinia kuehnii*, sooty mould, sheath spot caused by the fungus *Bakerophoma sacchari*, wilt caused by the fungus *Cephalosporium sacchari*, and leaf freckle, the cause of which is unknown.

The fundamental policy in cane disease control for the Hawaiian Islands, according to Mr. Lee, was to exclude those diseases occurring in other countries which had not yet reached this country. Control of most of these foreign diseases could be effected but it would cost money and it would be much cheaper to exclude the diseases than to combat them once they became established here.

Dr. Ishida listed the diseases known in Formosa, mentioning especially mosaic disease, red rot, pineapple disease, two kinds of root disease, and many other troubles which are in the course of investigation.

In Cuba, Dr. Mario Calvino, of Central Chaparra, mentioned mosaic disease and a trouble which he called blight.

The question of the importation of cane diseases on bamboo poles, or leaves used as packing material, was raised by Mr. E. M. Ehrhorn, Chief of the Plant Inspection Service in Hawaii. It was agreed by the delegates that such importations were a possible source for the admittance of organisms, possibly of minor importance on bamboo, but under certain climatic conditions or on certain varieties might be serious on cane. It was the consensus of opinion that the matter should be looked into more fully.

Gumming diseases were next discussed by Mr. North. Gum disease in Java was distinct from gumming disease in Australia, but was very similar to leaf scald which occurs in Australia. Leaf scald is characterized by leaf streaks which afford the chief symptom for identification.

These streaks become visible as soon as the leaf unfolds and turns green. The larger ones may even be faintly discerned in white immature leaves unfolded by hand. They occur either on the midrib or on any part of the leaf blade or leaf sheath. Some of them traverse the whole length of the leaf. As they strictly follow the course of the vascular bundles, those located on one side run out on the leaf margin at the top end. But the smaller ones instead of traversing the whole length may fade away after running a certain length. They are straight, well defined, narrow, even streaks, creamy, almost pure white in color. They persist as long as the leaf remains green, but with age they tend to broaden out and become diffused, afterwards withering; this process usually commences towards the leaf tip and works downward. Reddish spots or blotches may also appear on them. Numerous bacteria are found in these streaks in microscopic sections, located in the xylem elements of the vascular bundles.

In the stem, numerous reddened vascular bundles are to be found, more especially in the nodes. They even occur in the embryonic tissues almost up to the growing point. Shooting of the eyes is most pronounced, even the immature eyes near the growing point usually showing a tendency to shoot. The side shoots display symptoms (leaf streaks, etc.) analagous to those of the main stem. They are particularly valuable for identification purposes in more mature canes, because leaf streaks can often be found on them, when they have been obscured by withering on the leaves of the main stem.

Mr. North also described the leaf streaks of gumming disease. The streaks are not present as a rule when a leaf first unfolds, but they develop in the mature leaves, thus being found chiefly on the older leaves. They occur most commonly towards the leaf tips, but may occur on any part of the leaf blade. In color they are yellow and marked with tiny reddish brown spots. They are fairly straight but have irregular margins and do not so strictly follow the course of the vascular bundles as the leaf-scald streaks do. They keep on growing in length, the older portions withering and the leaf tending to split. Typically, the withered portions occur towards the leaf tip, but often streaks consist of a central withered portion, with a live yellow portion at each extremity. In rare cases, streaks are found present when a leaf unfolds and turns green, then having every appearance of having travelled up from the stalk below. These streaks sometimes closely resemble those due to leaf scald of the broader spreading type, especially if, as sometimes occurs, they are devoid of the brown spots and run the whole length of the leaf.

Dr. Lyon again emphasized the need for keeping leaf scald and gumming disease out of Hawaii, since he believed these diseases would be very serious here.

The matter of sectional chlorosis was brought up by Mr. Alexander. Mr. North stated that they had this trouble in Australia and that it was especially common on the variety D 1135. In Australia it was believed to be associated with cold weather when standing water existed around the central cylinder of the stalk.

Dr. Brandes said they had this trouble in Louisiana and had at first considered the cause of much the same nature as described by Mr. North. Later, however, they obtained the disease in their greenhouses in Washington, eliminating the possibility of its being associated with cold weather. He believed the trouble to be due to either extreme of temperature when there was an accumulation of water in the leaf spindle.

In Hawaii the disease has been reported from Olaa, Honokaa, Ewa and Waianae, according to Mr. Lee, but usually has disappeared without any serious harm, within one or two months. The theory of frost injury, as advanced in Australia, apparently could not be applied to such conditions as exist at Ewa and Waianae. The varieties affected have been D 1135 and H 109.

Sugar Cane Quarantine (By H. L. Lyon)

On Wednesday morning, July 30, the delegates of the cane sugar section assembled at the Territorial Plant Quarantine Station and inspected the laboratory and equipment employed in carrying out the local quarantine regulations.

They then visited the cane quarantine house of the Hawaiian Sugar Planters' Association. This house was not entered but was carefully inspected from the outside. The delegates next assembled in the administration building of the Sugar Planters' Experiment Station and engaged in a general discussion of the subject of sugar cane quarantine. The points of especial interest to Hawaii brought out in the discussion may be summarized as follows:

As the sugar cane plant was not indigenous in Hawaii, all diseases and insect pests specific to this plant now present in these islands must have been introduced from outside sources. It follows, therefore, that had adequate quarantine measures been in force from the very first, cane in Hawaii might still be nearly or quite free from its specific enemies.

Laws regulating or prohibiting the importations of propagating material of sugar cane can be considered detrimental only to the country making these laws. It is no hardship to any cane-growing country to have cuttings of its cane varieties refused entrance into any other cane-growing country.

Travel and commercial intercourse between countries afford many avenues through which cane insects and diseases may be transferred from one country to another. It is quite impossible to close some of these avenues and impracticable to close others by quarantine regulations. It is obvious, therefore, that no practical quarantine can afford absolute protection against the entrance of the insect pests and diseases of the sugar cane into new territory.

While the danger of general dissemination of cane insects and diseases will grow with the increase of travel and commerce between the countries of the Pacific, still the danger will, at the same time, be lessened through the growing knowledge of these pests and the application of successful measures of control in the various cane-growing countries where they occur.

It is quite possible to surround the importation of cane cuttings into a country with such precautions that the liability of introducing insect pests and diseases with the cane will be less than that attending ordinary travel and commercial intercourse. This condition has quite evidently been attained through the quarantine measures now in force in Hawaii.

While there is no case on record where a cane disease or insect pest has been transferred from one country to another on dry cane tassels, still it is quite possible that certain cane diseases may be carried on such material and importations of seed should always be handled with great care.

Sugar Cane Entomology (By O. H. Swezey)

The session of the sugar industry section of the Pan-Pacific Food Conservation Conference occurring on the afternoon of August 6, was devoted to discussions on sugar cane entomology. Mr. Swezey was the leader and at the beginning of the program gave a somewhat lengthy account of the major sugar cane insect pests in Hawaii, the history of their occurrence, whence they came, their habits and the damage caused. The method of controlling these pests by the introduction of natural enemies was outlined, with an account of the different parasites introduced for the respective pests.

Pest	Introduced Parasites	From
Cane Borer, *Rhabdocnemis obscura*	*Ceromasia sphenophori*	New Guinea
Leafhopper, *Perkinsiella saccharicida*	*Paranagrus optabilis*	Australia
	Anagrus frequens	Australia
	Cyrtorhinus mundulus	Australia
	Ootetrastichus beatus	Fiji
	Haplogonatopus vitiensis	Fiji
	Pseudogonatopus hospes	China
	Ootetrastichus formosanus	Formosa
Root grub, *Anomala orientalis*	*Scolia manilae*	Philippines
Aphis sacchari	Several ladybeetles	Australia
	Micromus vinaceus	Australia
Leafroller, *Omiodes accepta*	*Chalcis obscurata*	Japan
	Microbracon omiodivorum	Japan
	Trichogramma minutum	U. S. A.

Mr. H. Freeman, of the Colonial Sugar Refining Company, gave an account of experiments in the control of the cane grubs in Queensland. The two species most injurious to cane there are *Lepidoderma albohirtum* and *Lepidiota frenchi*, and loss by their grubs often is as much as 60 per cent. The adult beetles have their flights at certain definite seasons, and "it was found that there were two main reasons why any particular field of cane was selected by the beetles for the deposition of eggs. These were: (1) the height of the cane, and (2) the proximity to feeding trees. As an example, it was found that fields of cane which were six to nine feet high at the time of the beetle flight were infested to extent of an average of 6 to 14 grubs per stool; whilst cane which was only 6 to 18 inches high averaged considerably less than one grub per stool. From this a control measure was evolved in which a fast growing variety was planted during the beetle flight and pushed ahead by the use of a suitable manuring program." The beetles went to other fields of higher cane for egg laying and this field grew a crop without infestations. By harvesting fields just before the beetle flight, the new ratoons would also similarly escape becoming infested.

This control measure could not be utilized on all fields on account of various labor considerations. By experiment it was determined that a saturated solution of paradichlorobenzol in carbon bisulphide was 2 or 3 times as efficient as either of the constituents used alone. A mortality of 80 per cent to 90 per cent of the grubs was obtained by using this fumigant. The increased yield obtained due to the fumigation made it a profitable investment. This fumigation had no detrimental effect on the growth of the cane providing it was over 4 or 5 months old. Younger cane was seriously affected.

Mr. Barnett, also of the Colonial Sugar Refining Company, told of the cane borer Tachinid being established in northern Queensland, and that it is being distributed to other parts of the State. He also told of its being established and doing well on the Rewa River, Fiji, but that it has not succeeded on the opposite side of the island, though continued efforts have been made to establish it there. The borer has destroyed as much as one-third of the season's sugar crop at one center. Referring to a recent report by Mr. Veitch, Entomologist of the Colonial Sugar Refining Company, Mr. Barnett discussed some minor pests of sugar cane in Fiji. Among them was the armyworm, and he spoke very highly of the value of the mynah bird in preventing armyworms and grasshoppers from becoming extremely destructive pests.

Mr. Ishida, Chief of Shinka Sugar Experiment Station, Formosa, read two papers, one on "The Application of *Metarrhizium anisopliae* for the Control of *Allisonotum impressicole* and Allied Beetles," in which it was shown that the use of the fungus reduced the number of beetles and grubs about 50 per cent; the other paper was on "The Application of *Phanurus beneficiens* Against Stalkborer and its Result." This is an egg-parasite introduced from Java in 1916, and it has succeeded so well, along with other egg-parasites already present, that at present the damage to the cane from stalkborers is not serious.

Professor Osborn, of Ohio State University, who has made much study of leafhoppers and their economic importance, cited cases of the migration of some species from tropical America north into the United States, and warned of the likelihood of such species becoming pests in the new places they invaded. He said that in a recent letter from an entomoligist in Africa, the corn leafhopper was said to have been found infesting cane. It has never yet been known to do this in Hawaii.

Dr. Williams, who had recently returned from a two years' parasite trip in various South American countries, read a paper on "Insects Affecting Sugar Cane in South American Countries." In this paper the worst pests in various places respectively were: Barbados—root grubs, *Phytalus smithi* and *Diaprepes abbreviatus;* Trinidad—the froghopper, *Tomaspis varia;* British Guiana—moth borers, *Diatraea* spp.; Brazil—froghoppers and *Ligyrus* beetle; Ecuador—moth borers, *Diatraea* spp. and weevil borer, *Metamasius.* Many other minor pests were mentioned. The most of these cane pests are insects native to the regions, and previously feeding on other plants, but have taken to feeding on cane after the introduction of the latter by man. Some of them are partially controlled by natural enemies.

Mr. Kay stated that the principal cane pest in Porto Rico is the white grub.

Professor Cockerell, of the University of Colorado, stated that he had noticed by a report from the entomologist in Egypt, that the mealybug, *Pseudococcus sacchari,* was the worst cane pest they had there, and that it really threatened the prosperity of the sugar industry in Egypt. While in Madeira Islands a few years ago, Professor Cockerell had found this same mealybug, but exceedingly scarce, apparently being destroyed by the larvae of a small *Leucopis* fly. This should be worthy of investigating further, for it might be that the fly could be introduced to Egypt or other countries desiring enemies to this particular mealybug.

Mr. Pendleton reported termites to be the worst cane pests in Gwalior State, India. They often eat the seed before it begins to germinate. If they do not attack the cane until it is pretty well grown, they work up through the stool in the inside of the cane, filling the stalk with mud as they go. Many insecticides have been tried, but all ineffectual. The second pest is the cane borer.

In the absence of Mr. Van Zwaluwenburg, of Los Mochis, Mexico, Mr. Swezey presented for him a paper on the "Insect Enemies of Sugar Cane in Mexico." Two Pyralid moth borers, *Chilo loftini* and *Diatraea lineolata*, were mentioned as the only serious enemies of sugar cane in the state of Sinaloa, the former being by far the more important. No field methods for controlling it have been found. It infests many grasses, also corn, sorghum, and rice. A few native parasites attack this pest, chief among which is a *Chelonus* that has been known to parasitize as high as 23 per cent. Although second in importance, *Diatraea lineolata* has been known to infest from 35 per cent to 60 per cent of the cane stalks. It is primarily a pest of the plant cane. This is better controlled by natural enemies than *Chilo*.

The eggs are often parasitized to the extent of 70 per cent by *Trichogramma minutum*. In one state a Braconid, *Apanteles diatraeae*, has parasitized as high as 50 per cent. Attempts have been made with introduction of four parasitic flies, two from Cuba, one from Vera Cruz, and one from New Orleans, but so far none of them have been recovered. Minor cane pests in Mexico are: armyworms, leafhoppers, froghoppers, Membracids, the cane lacewing, mealybugs, and a weevil borer, *Sphenophorus incurrens*.

Rodent Control (By C. E. Pemberton)

In the session of the sugar section of the Food Conservation Conference devoted to rodent control, it was of particular interest to learn:

1. That rats actually do cause serious losses to cane in other countries. For instance, Mr. M. S. Barnett, of the Colonial Sugar Refining Company of Australia, stated that in 1921 a loss of 4 per cent of the total crop at two of their Australian mills, was attributed to rat activities.

2. That systematic poisoning has been proven effective in rat control in Australia and Cuba, though it has not been so extensively conducted as in Hawaii.

3. That phosphorus is the favored poison in Australia, and strychnine in Cuba. Barium carbonate has apparently not been tried in other countries to any great extent.

4. That rats are not so chronically serious in other cane countries as in parts of Hawaii, and that this condition is probably owing to the presence of natural rodent enemies such as snakes, owls, and hawks, in those countries. Mr. H. Freeman referred to the carpet snake of Australia, stating that it was common in some cane fields and that he had in many instances found the remains of rats inside them. Mr. Barnett also stated that these snakes had been seen to catch rats in buildings in Australia. They are not poisonous. Mr. Wood, of Cuba, also referred to two non-poisonous Cuban snakes which are said to be good ratters. Dr. F. X. Williams noted a non-poisonous British Guiana snake known as the "Yellow Tail," which is considered a very good rat catcher.

Interesting mention was also made by Mr. Barnett of useful hawks in Australia; by Dr. Williams of a beneficial bird of prey, the Caracara of Ecuador; by Mr. Wood of an iguana, owls, and hawks, of Cuba; and by Mr. Freeman of a so-called iguana of Australia, and of useful hawks. All admitted that these various natural enemies of rats had a weakness for chickens.

5. That rats in Australian cane fields damage cane only in sections of fields adjacent to permanent water supply. This point, brought out by Mr. D. S. North, is of particular interest, because rat damage in Hawaiian cane fields shows no relation, so far as observed, to the availability of water.

Sugar Cane Breeding (By Twigg Smith)

The good results that have attended careful crossing of sugar cane varieties is creating more interest in this type of seedling propagation.

The object of all cane breeding work is to obtain a cane which will have a combination of the qualities that are necessary for the production of a high sugar yield. Many canes otherwise good are weak in stooling or subject to attacks by disease.

Again, a hardy, heavy tillering cane may not produce enough sugar to make it a commercial cane.

The combination of good qualities of different varieties, then, would constitute the super-cane.

An endless amount of effort spent year after year in producing hybrids, by any method, from any two varieties, has little chance of success in producing the super-cane unless (a) proper study is given to the inherent characteristics of the parents; (b) their behavior under climatic conditions where the seedlings are to be grown commercially; (c) whether their characteristics, desirable and undesirable, are capable of being transmitted to their hybrid offspring.

Already certain characters and qualities of sugar cane have proved to be transmissible.

The discussion for the most part was by men actually engaged in sugar cane breeding work. The outline presented by Dr. Brandes for thorough discussion of the subject follows:

1. Selection of parents.
2. Varieties naturally inclined to bloom.
3. Environmental conditions affecting blooming or maturity.
   a. Latitude, daylight.
   b. Altitude.
   c. Temperature.
   d. Drought or excessive rain.
4. Technique of crossing.
   a. Methods for determining viability of pollen:
      (1) Iodine test.
      (2) Germination on stigmas of other plants.
      (3) Germination on sugar solutions.
   b. Methods for collecting and preserving pollen.
   c. Periodic viability of pollen during blooming season.

d. Methods of applying pollen:
   (1) Dusting.
   (2) Suspending male panicles.
e. Diurnal variation in opening of florets.
   (1) Receptive period of stigmas.
f. Protection of fertilized flowers against contaminating pollen:
   (1) Cloth bags.
   (2) Waxed paper bags.
   (3) Isolation by distance.
g. Harvesting of seed:
   (1) Bagging previous to maturity.
h. Viability of perfect seed:
   (1) Time to plant.
   (2) Time required for germination.
i. Methods of planting:
   (1) Rate of planting and position in relation to medium.
   (2) Soil.
   (3) Water requirement.
   (4) Provisions for preventing seed mixtures or pot contaminations by wind.
j. Transplanting—elimination of undesirable seedlings.
k. Packing seed for shipment.
l. Uniform methods for designating parents and time of producing seedlings by standard record.

Dr. E. W. Brandes said: "If we hope for progress in the way of actually improved varieties we have to go into breeding much deeper than just taking any two canes and crossing them: we must make a study of the possibilities that lie in the various varieties and fit them in with the various problems that have to be met. Conditions may arise, such as the introduction of a new disease, which may make new varieties necessary."

Selection of Parents: Under this heading it was stated that each country had its disease troubles, and the natural desire is to get a cane that would be immune to disease and at the same time be a good sugar producer.

In Hawaii, efforts are being made to combine the desirable characters of H 109, Badila, and D 1135 on one side, with the hardier, disease-resistant and heavy stooling character of Uba,* in an effort to avoid eye-spot, root-rot, yellow stripe, mosaic, etc. Also the so-called Tip canes are being crossed with D 1135 for higher lands. The Tip canes are vigorous growers at high elevations, but susceptible to mosaic and to red stripe disease. On the other hand, D 1135 is very resistant to eye spot, mosaic, and red stripe disease, and ratoons well, but does not do as well as the Tip varieties above 1500 feet elevation.

We are also trying many field-gathered crosses of H 109 and D 1135.

Mr. Clarke said that in Fiji, Badila is favored as a mother cane, and they would like a combination with such a cane as Yellow Caledonia or H 109.

Mr. Ishida said that in Formosa, their main enemy is sereh, and that effort was being made to get seedlings resistant to it. They are trying several varieties, including Yellow Tip, Rose Bamboo, Badila, and Kassoer.

In Cuba, Dr. Calvino stated that Uba, with D 74 as a male parent, had been useful in producing disease-resistant seedlings. They also imported seedlings from

* The Hawaiian grown cane of the Chinese type called "Uba;" probably not the same Uba as that of other countries.

Barbados and British Guiana. The parentage was not stated. Dr. Calvino said they took a great interest in raising seedlings because the seedlings may show characters which were not apparent in the parent canes.

Mr. Pendleton said that the problem in northern India is to produce a thick cane that will grow well under adverse conditions, notably, low humidity, little irrigation, and serious infestation of termites. In reply to a question, he stated that experiments had demonstrated that the thin-stick North Indian varieties were outyielded by their hybrids having larger sticks.

The question of transmission of susceptibility to disease by parents to seedlings was discussed at considerable length.

Mr. Agee cited the case of H 109, an Hawaiian seedling which is planted to 70,000 acres and gives very high yields and is immune to what is termed Lahaina disease or root rot. This cane is a seedling of Lahaina, which is extremely susceptible to the disease. The seedling H 109 was produced without knowledge of its male parent, but it is thought to be Rose Bamboo or the family to which Rose Bamboo belongs. Rose Bamboo is also susceptible to Lahaina disease. Both Rose Bamboo and Lahaina failed at Ewa plantation, where the world's record yields have been made by their progeny, H 109. Another instance is a cane we call the Uba Hybrid No. 1. We were very desirous of obtaining a cane immune to yellow stripe disease. Following the lead of Dr. Calvino of Cuba, we crossed Uba with D 1135, both parents being commercially resistant to yellow stripe. The hybrid No. 1, however, has well developed cases of yellow stripe or mosaic.

"I think," said Mr. Agee, "that these two cases prove that we cannot be too closely bound by theory in cane breeding."

Dr. Brandes expressed the opinion that the cases mentioned by Mr. Agee were exceptions which prove the rule that like produces like, and that a cane immune to disease has a greater chance to produce immune offsprings. He also pointed out that he had seen yellow stripe on D 1135 in the Philippines.

Mr. Agee stated that at Honokaa a fair percentage of Uba seedlings had yellow stripe disease. It was important, he thought, to note and study these exceptions to what might be expected. It is not the characteristics of the parent canes that we are primarily concerned with, but the characteristics that they are capable of transmitting to their progeny.

Dr. Brandes stated that in trying to get a variety resistant to sereh, in Java, they had crossed their Black Cheribon with Chunnee from northern India. They succeeded in getting seedlings, immune to sereh, but susceptible to other diseases, notably, yellow stripe or mosaic. At the present time they are concentrating on crosses of native canes and the primitive types of sugar cane. The seedlings obtained are then crossed with the heavy-yielding canes, and they have now several promising seedlings, such as P. O. J. 2714, 2725, etc., which are resistant to most diseases. Many of them are commercially immune to mosaic and also the disease referred to as root disease.

Mr. Barnett stated that in the case of a New Guinea variety called Mahona, imported to New South Wales, it was noticed that it had a tendency to die off in the tropics, due, it was discovered later, to a disease called leaf scald. Many seedlings had been raised from Mahona, and the majority inherited susceptibility to the disease.

Under the topic of "Blooming or Tasseling," it was brought out that all varieties bloom in Hawaii, and it seems well established that the blooming is best in the medium altitudes. Instances were cited where, on Hawaii, cane did not bloom at 3,000 feet nor at 50 feet, but did bloom between these levels.

It was stated that all varieties bloom at times in Fiji and Formosa.

It seemed generally accepted that anything that checks the growth of the cane seems to cause the plant to arrow, tasseling being considered a normal process of sugar cane.

Under the heading of the "Technique of Crossing," the first discussion was on the methods of determining the viability of pollen. The method favored at present at this Station is to determine by miscroscopic examination if the pollen is spherical and contains granules, in which case it is considered normal. The presence of starch as indicated by the well-known iodine reaction test is in exact relation to the normal state of pollen grains, which are spherical, juicy, and full of granules of starch. It was stated that in Hawaii there was no success in germinating pollen on any of the artificial media tried last year.

Dr. Calvino told of success in germinating pollen on stigmas of other plants, but not in any solution. Mr. Clarke reported a complete lack of success in germinating pollen in any way in Fiji.

Dr. Brandes said that in Florida they had successfully used the moon vine, a species of *Ipomoea*.

In Hawaii, the method of collecting pollen has been to suspend the tassels over a table, which is covered with black paper, and as soon as the pollen had dropped, to sweep it into a container and immediately dust it on the stigmas. No satisfactory method of preserving pollen has been found; rather, it seems to be very fugitive, quickly drying under changes of temperature and humidity. It has never been possible to keep it looking spherical above 10 minutes if exposed to much light.

Under the topic of "Periodic Viability of Pollen," Dr. Brandes pointed out that observation had been made in many places that pollen may be viable at the beginning of the tasseling period and worthless toward the end, and that it is extremely important that we should know just the best time, with each variety we desire to use, to take pollen for cross pollination. The period of non-viability of pollen would be the best time to use that particular variety as a female parent.

No definite data appeared to have been kept as to the best method of applying pollen to the stigmas of the female variety.

Good results have been secured in Hawaii by two methods, tying the male and female tassels together, and by collecting the pollen on paper and brushing it on the stigmas.

Speaking on the variation in the receptive condition of stigmas, Dr. Brandes stated that under local conditions in Florida it had been found that stigmas of sugar cane were receptive from 3:40 A. M. till daylight.

It was generally agreed by those who had used bags to protect the tassels that it is not to be recommended. The tassels are weakened, and germination of the seed is weakened. In general, where a large number of seedlings are wanted, it seems to be considered enough to gather the pollinated tassel in the field from a place where it is fairly reasonable to suppose the desired cross has been effected. Until some method of carrying on artificial cross pollination on a large scale is found, this method of getting crosses will probably continue in most countries.

Dr. Brandes stated that in Florida they now make a practice of waiting a week or so after the last male tassel has been placed in contact with the female, and then put a cloth bag over the pollinated tassel to prevent wasting of prospective seedlings. In Hawaii, the practice is to wait till the fuzz flies from the top of the tassel on being lightly tapped. The tassel is then considered ripe enough to gather. Sometimes the panicle is cut in sections for planting so as to avoid the loss of mature parts.

The time that seed can be held before being planted seemed to vary in each country. In general it seemed that the sooner it was planted the better, although Dr. Brandes told of seed sent from India to Washington, D. C., which germinated very well.

On the question of how long the fuzz should be kept in the hope of germination, it was brought out that cane tassels had continued to give germination for as long as thirty days.

Mr. Kutsunai outlined the Hawaiian method of planting seed, which is to distribute the fuzz on top of sterilized garden soil and sand. The fuzz is kept very moist.

The method of Mr. W. P. Naquin, at Honokaa Sugar Company, of using well-seasoned filter press cake alone, on which the fuzz was spread, has given remarkable results, and probably is as good a medium for getting germination as any used so far.

Dr. Brandes said the U. S. Experiment Station in Florida uses clean fresh-water sand, which is practically sterile, and from which they have had good results.

Mr. Clarke stated that in Fiji they use a glass house, and the temperature ranges from 120° in the day to 60° at night, but even at that they get very excellent germination.

Mr. Agee stated that large cold frames with glass protection were used very successfully in Kohala and Hamakua. These gave a very high temperature.

Steam heat will be tried as a subsoil heat this year in Hawaii, and Dr. Brandes stated it was his intention to try the same in Florida.

Also this year in Hawaii some seedlings will be germinated in a glass house so made that it will be possible to roll the flats out in the fresh air on still, dry days. The time of germination in Hawaii is January and February, which are normally the wettest months.

In discussing the elimination of undesirable seedlings it was brought out that in Fiji, Formosa and in Florida it is customary to discard by inspection, after one year's growth, from 95 to 98 per cent of the canes. In Hawaii, the initial discard is not so high, usually being from 60 to 80 per cent, sometimes 90 per cent.

Dr. Lyon questioned the advisability of severe elimination of canes the first year, and thought that there was an opportunity for valuable scientific investigation in this connection. Both he and Mr. North cautioned against selecting with a preconceived type in mind, feeling that the superior cane sought in this work may appear in a form different from the commercial canes of today. Mr. North cited Badila as an example of a valuable cane which would be eliminated if grown in competition with other varieties closely spaced about it.

Mr. Moir strongly favored ratooning the original seedling plants and cited the Wailuku seedlings in support of his contention. Initial selections based on plant cane were found inferior by him to canes originally overlooked and afterward selected by him from the old ratoons of the original plants. Mr. Kutsunai pointed out that at the Manoa substation a large number of seedlings were being ratooned this year from the original plants, and he stated that with one exception he had been able to select as plant cane those seedlings which afterward showed to good advantage as first ratoons.

On the question of the spacing of the original plants, it was found that spacing of four or five feet was utilized in Fiji and Formosa and even wider spacing in Florida. In Hawaii, a spacing of plants three feet apart in five-foot rows has been gradually reduced to two feet. On the strength of recent trials of five-foot spacing, however, there is an inclination to adopt this in the future.

Dr. Brandes described a score card system of judging canes with the view of reducing to a minimum the personal equation in selection. Cane breeders in Hawaii, Fiji and Formosa agreed to give this score card system a trial under their conditions. Dr. Brandes laid great emphasis on the strong root system. This, he said, must be considered as a prerequisite of any seedling that is to be retained.

It was also pointed out that when one adopts wider spacing or is slower in eliminating apparent undesirables in a large block of seedlings, he thereby curtails the space that might be devoted to newly propagated ones. To thus reduce the number of germinations is in effect an elimination in itself of those not germinated, and this must be borne in mind in any further study to perfect our methods.

Bud Selection (By Y. Kutsunai)

Mr. Harry Flockton Clarke, of Fiji, presided at this meeting.

That there are mutations of sugar cane is an established fact. The sporting of Striped Mexican into Rose Bamboo, of Red or common D 1135 into yellow-striped D 1135 and bronze-striped D 1135, and finally into the so-called white D 1135; of H 109 into striped H 109, and of Yellow Caledonia into striped Caledonia of various colors, is very well known in all cane countries and needs no evidence to prove its occurrence. The color mutations are naturally the first to be noticed because the mutating qualities are not only clearly visible but also are *independent* of the environmental factors.

The heavy-yielding mutations, which are also thought to exist, as indicated by several tests, are not clearly seen on account of the overpowering environmental influences. How often these heavy-yielding mutations occur and recur in the cane fields is not definitely known at the present state of knowledge of the subject. The frequency with which the striped sport of H 109 occurs may possibly throw some light on the point in question. Eight stools of striped H 109 were found in about 25,000 stools of H 109, or a ratio of 1 in 3,000, roughly. A high-yielding mutation, if rare, as it is thought by some to be, and masked by the environmental factors is not easy to spot. The history and the methods of selecting or isolating high-yielding mutations so far evolved or suggested, and the attending difficulties were well discussed and many points of interest were set forth. A review of these points and ideas follows.

The work of selecting mutations in sugar cane by Mr. A. D. Shamel was begun in 1920. His first activity was that of training a staff of selectionists to develop keen powers of observation. The course consisted of taking a very detailed census of a cane row, noting the position of the stalks, the number of stools per seed piece, the number of stalks arising from a single eye, the length, circumference, and weight of the stalks, the number of joints in the stalks, juice analyses, color types, and uniformity.

When the staff became sufficiently acquainted with the cane plant, the actual selection of superior stools was initiated. The cane selected was always plant cane.

The fundamental idea of the bud selection is to segregate a given variety of sugar cane into its component strains and at the same time to isolate any mutation that may exist or be thrown out in the course of work. From such strains and mutations, the high-yielding lines are to be isolated. These isolated lines may revert back to the original variety or may throw off other new lines.

Two lines of procedure have been developed. In one, a plot of cane is stripped and every stool is examined. Superior stools of cane are chosen for further trial. Due allowance is made for extraneous influences, such as a near-by watercourse or a ditch, proximity to the edge of the field, etc., at the time of judging the stools. The other method consists of covering as wide an area as possible, without the preliminary stripping and picking out of very striking stools, and planting them under uniform conditions for further selection.

In applying the theory of bud selection to practice, two tendencies have been developed. In the one case, the selectionists have laid stress on the so-called types, or conformation of sugar cane. The erect, semi-erect, and the recumbent types of H 109 have been studied carefully in relation to the yielding power of the types. The selectionists of this school hold that a variety of sugar cane, H 109, for instance, is made up of many strains that are well nigh stable. The segregation or resolving of a variety into its component strains is followed by the comparative studies of the segregated strains in order to find the most desirable one. The other school believes that the high-yielding quality of a variety of sugar cane may be correlated with two kinds of characters, visible and invisible. Selection based on this idea is necessarily very wide in its latitude. Not only all the promising types are accepted, but also all the superior stools are selected for further trial.

The selection work seems to be a rather involved proposition on account of the overwhelming environmental influences which obscure the differences in the yielding qualities of various strains of a sugar cane variety. Consequently the work is now taking a decided turn and the problem of the immediate future is the development of methods by which the disturbing environmental factors may be unified or held in check. The most important cause of the difficulty is the uneven distribution of the elements on which the cane makes growth, such as light, fertility, and water. The "necessities of growth," if allotted to each stool in equal amounts, the inherent characters of the stools become apparent. The method that promises to, in part, fulfill the desired aim, is spaced planting. The selected stools are planted far enough apart so that each stool can have more room for natural development.

Another turn that is taken in the procedure of bud selection work is the study of ratoons. Heretofore most of the work was done in plant crops about a year old. It is reported that a ratoon crop, especially an old ratoon crop, has been noted to be very promising material for selection.

On the whole, the problems confronting selectionists are very much more involved than anticipated. Unless one is fully prepared to meet discouraging results, and unless one has firm conviction and faith in the work, and has originality and resourcefulness to overcome the stumbling blocks that beset the work of bud selection, he is likely to fall short of his goal.

Sugar Cane Cultivation (By J. A. Verret)

The meeting was presided over by Mr. Hunter Freeman, of Australia. Those taking part in the discussion were Messrs. M. S. Barnett and H. Freeman, of Australia; Mr. H. F. Clarke, of Fiji; Messrs. Kintaro Oshima and Migaku Ishida, of Formosa; Mr. R. H. Van Zwaluwenberg, Mexico; Dr. Mario Calvino, Cuba; Mr. R. L. Pendleton, India; and Messrs. H. P. Agee, Guy R. Stewart, W. P. Alexander and J. A. Verret of Hawaii.

We shall outline briefly important points brought out in discussions in the order in which they were presented.

Rotation and Green Manuring: Dr. M. Calvino, speaking for Cuba, pointed out that no rotation is practiced in Cuba, and no irrigation. In a few cases some green manuring is being done experimentally. The velvet bean is used for this purpose with good results. Jack beans have also been tried. The velvet beans are planted broadcast, and plowed in before they mature seed.

Mr. Pendleton, speaking for India, said that agricultural conditions were rather poor in that country. In preparing the land for cane, a wooden, steel-tipped plow is used. This goes down, at the most, about four inches. But the Indian farmers make up for this to some extent by plowing the land as much as twenty times before planting.

A system of rotation for sugar cane has been recently introduced with promising results. It is one of three years, and starts with sugar cane, planted in the winter season. This grows for one year, and no ratoons are taken. After harvest the land lies fallow until the rainy season, about June or July, when san hemp, *Crotalaria juncea*, is planted. This is plowed under in September, after which the land is planted to wheat. This crop gets one or two irrigations, and is harvested in March or April. The land remains idle until June, when another legume, guar, *Cyamopsis psorolioides*, is planted. This is cut about September, and used for fodder, sometimes being made into silage. Cane follows this, being planted about December, starting a new cycle. Some irrigation is practiced. This applies especially to northern India. The yields are rather small in India, 18 tons of cane per acre being about maximum.

In Fiji there is no irrigation. As a general rule three crops are raised, one plant and two ratoons. This is followed by a green manure crop, black Mauritius beans usually. A fair crop of beans gives about 10 tons of green matter per acre. This is plowed under.

In regard to trash conservation, Mr. Clarke, speaking for Fiji, made the following statement: "Formerly we saved the trash. This was made into piles between the cane rows and after the harvesting of the last crop this accumulation of trash was plowed under. We found a certain benefit from this, but we also found certain disadvantages. The ratoons were hampered in their growth by the banks of trash, which did not rot readily. At that time we were only growing plant and first ratoon crops. Now we do not save any trash except that from the last ratoon crop."

Mr. Van Zwaluwenberg, referring to the western part of Mexico, said that irrigation was the common practice. The fields are ratooned from two to four times. The old lands generally raise but two ratoons. The cane is followed by alfalfa. This grows for two years, cutting the first year and grazing the second. In some cases a short cover crop is put in. This is planted in May or June, and grazed. Cane follows, being planted in the fall or spring. The cane grows for 18 months to 2 years.

In Formosa, some areas are irrigated and some are not. The cane crops consist of one plant and one ratoon. This is followed by a crop of sweet potatoes, and this in turn by peanuts. Cane ratoons very poorly in Formosa.

In Louisiana, a three- or four-year rotation is followed. This consists of one plant crop of cane, one ratoon, and then corn and cowpeas, the cowpeas being plowed under. The four-year rotation is the same except that there are two years of cowpeas and corn instead of one. Cane in Louisiana is about a 9 months' crop. Frosts kill the cane down in winter. These frosts are likely to come along any time from November to March. The average yearly yields of cane vary from about 11 to 18 tons per acre.

In Queensland and New South Wales, the practices are given as follows by Mr. Freeman: "The plant crop is usually about 15 months old and the ratoon crop occupies the land for 12 months. Generally speaking, we cut two ratoon crops, but on some occasions it runs to third ratoons. This depends upon the prospect of a profitable yield. The trash is certainly not saved. The period of fallow varies, but usually it is only a matter of time sufficient to prepare the land for a subsequent crop. Undoubtedly there are farms that practice green manuring, and they find the benefits of it. It gives handsome yields in Queensland. I think there are various reasons for that, but mainly it serves as a weed control, and supplies humus. The green manure crops are Mauritius beans and cowpeas. Of these the Mauritius bean is undoubtedly the better, for the reason that it holds the ground longer. But it must be plowed under before it produces seed. The ground is well covered for four or five months. We get maximum yields of 10 to 15 tons of green matter per acre. In Queensland we might say that the average cane crop is about 20 tons per acre. We get maximum yields of 60 to 70 tons per acre from year-old crops, but they are exceptional, and these only occur on new lands, recently brought under cultivation. In New South Wales, the climate is colder and the rainfall more even. There we have two-year-old crops of both plant and ratoon cane with yields of 50-100 tons per acre. Very little green manuring is regularly practised, but there is a certain amount of rotation with corn. There is very little done in the way of green manuring, either in Queensland or in New South Wales, but we feel the want of it very badly. There is one point in connection with green manuring that may interest you. For instance, with Mauritius beans, sown broadcast, we use a bushel of seed to the acre, whereas with a drilling machine half that quantity is sufficient, and one man can cover four to five acres per day. It is quite evident that there are many different opinions on the question of rotation practice. Hawaii stands in marked contrast to the other countries in getting increasingly better results without either resting the land or by green manuring. After thirty years of cane growing here, they still get increasing yields from the same land, but in Queensland the opposite is the case. The longer we grow the cane there, the lower the yields, unless we practice green manuring."

Preparing a Field for Planting: New lands in Cuba are not plowed, as these are generally forest lands. Holes are made among the stumps with picks or other sharp instruments, and the cane planted in them. On the lands which are plowed, some of the smaller tractors are used, plowing to less than 12 inches. Oxen are still very extensively used for plowing.

As stated above, the Indian uses a steel-tipped wooden plow for his plowing, with which he may scratch the field 20 times. The other work is largely by hand. The manure is placed in the furrow and well mixed with the soil about six weeks before planting.

The cane is irrigated and has frequent cultivations, gradually filling in the furrow so that by the beginning of the heavy rains in June or July the cane is well hilled.

In Fiji, in plowing in trash, a 4-mule, single-furrow plow, with a 26-inch disk, is used. The furrowing is done with a double mould board to a depth of 7 or 8 inches.

Some steam plowing (Fowler) is done on one plantation. Some tractors are used, the largest being about 45 h. p.

In Formosa, native plows and some tractors are used. The native plows go in about 5 inches. Seven or eight sets of Fowler steam plows are also used. Tractors and steam plows are used on the large plantations only. The small farmers confine themselves to the native plows. Fordson and Case are types of tractors used.

Mr. Freeman gave an interesting resume of the work in Queensland and New South Wales. We quote him: "In regard to Queensland and New South Wales, the plows are of various types. Usually disc plows are used in all preparatory cultivation work. One of the great obstacles in returning humus to the soil in preparatory cultivation has been the difficulty in finding plows suitable for turning under trash or bean crops. Special study has shown that a single furrow disc plow gives best results. The secretary disc is very satisfactory in so far as it has an arched beam which allows of great clearance. But we have modified the first furrow wheel and land wheel by using parts from more up-to-date plows, whilst the rear furrow wheel has been substituted by a disc Coulter. The sharp edge of this Coulter bites into the bottom of the furrow at the junction of the land and the furrow. Thus, by means of thrust, we have achieved what most plow manufacturers try to attain by weight. In consequence of this device, the plow is held to its work. Another point in regard to the satisfactory plowing under of green crops is that the disc needs to be as upright as possible; it must be at least 28 inches in diameter, and the edge kept as sharp as a razor by means of a long bevel and the constant use of a file. The dish of the disc should also be quite pronounced, and the furrow cut by it a full 12 inches. It is just these details which mean successful plowing.

"We believe that the desirable depth of cultivation is about 12 inches, but do not always achieve that. We are using more and more tractors every day. Steam cultivation is not used. My opinion is that a track-laying tractor is the only type to use. Many of the smaller tractors which work with one wheel in the furrow are employed. These are not necessarily preferred, but it is more a case of the inability of small farmers to purchase the larger or more efficient implement. Tractors give us a greater independence of labor by reason of their speed, and this speed is also a factor of importance in fitting in our work with weather conditions. They help us in labor problems, but, I am sorry to say, do not always mean more efficient work."

Planting: In India, whole stalks are planted without cutting, no top seed being used. The fields are irrigated ahead of planting, and the seed buried in the mud by hand (or feet, perhaps is a truer expression).

In Fiji, planting material is obtained from special fields called "seed beds." These are about ten months old when cut, and the whole stalk is used. In planting, the seed is placed 2 feet center to center, with rows 5½ feet apart. The seed is covered with ½ to 1 inch of soil in the rainy season and with about 3 inches in dry weather. When planting is done in the spring top seed is used, as the "seed beds" are not then ready.

These "seed beds" are carefully observed, and if any diseases, such as Fiji disease or mosaic, appear, the field is discarded for seed purposes. On this account both Fiji disease and mosaic appear to be under control, there being but little of either.

Except for this careful inspection for disease, these "seed beds" are not treated differently from the other fields.

In Cuba, as mentioned previously, forest lands are planted with a pick, using short seed. Another method is by means of a sharp, hardwood stick. The laborer walks along, and, at proper intervals, drives the stick in the ground at an angle; the stick is pressed up and pulled out, after which a seed is placed in the hole and the ground pressed about it with the feet. The advantages claimed for this system are that the seed has the benefit of the moisture in the bottom of the hole, and aeration, sunshine and heat at the surface.

Another system being tried out on a commercial scale was described by Dr. Calvino. This is called the Abreu system.

In this system the land is prepared and two seeds are planted in squares eight feet each way and covered with an inch of earth. No holes are used. At harvest only mature stalks are taken, the others are allowed to grow. As we understand this, mature stalks mean all millable cane. The stalks left behind are the immature suckers. Wagons are driven in between the cane rows to haul the cut cane.

In Formosa, both top seed and body seed are used. The seed is planted at an angle of 60° to 70°, and spaced 14 inches in four foot rows.

Mr. Freeman has briefly outlined conditions in Queensland as follows: "In regard to Queensland, usually we take seed from plant crops if possible. Some fields are often planted as seed beds, but no special precautions are taken in regard to them. In many cases seed cane is purchased from a neighboring farmer, but usually it comes from his own farm. We prefer plant cane about 9-10 months old. The seed is cut at right angles to the stalk and the ends are not shattered. This is possible with a soft cane like Badila, but the hardness of H 109 might force us to cut it on a slant as is done in Hawaii. We are afraid of the slanting cut on account of the greater area exposed to drying out. We usually use the whole stalk, but experimental evidence has shown that the tops give increased yields and slightly sweeter juice. These experiments were very carefully conducted. We do not soak the seed cane in water before planting unless the conditions are very dry. It is then a distinct advantage. Hand planting is a thing of the past. Queensland was the inventor of machine planting. It is a question of labor shortage, and I do not doubt but that very shortly you will be using machine planting here. These machines are of simple construction, consisting essentially of a box on wheels with a funnel through which the seed is dropped into the furrow whilst two feet on the rear of the machine cover over the pieces. Usually they work in the furrow, which has been made by a double mould board plow. The main feature about them is that they do the work well and save labor. Two units of labor will do more than five times as much work with the machine as they can with hand planting."

In Louisiana, whole stalks are used for seed. The bulk of these come from the poorest ratoon fields, and up to very recently no attempt was made at selection. Planting takes place in autumn or spring. The autumn planting takes place in September or October, before harvesting begins. The spring planting starts in February and proceeds as fast as weather allows. The seed for spring planting has to be kept over winter and protected from frost. This is done by cutting two rows on one, placing the cane in the furrow and covering with earth several inches deep. This keeps fairly well through the winter. The autumn planting remains in the ground all winter and begins to germinate in February or March, depending on the coldness of the season.

It is now becoming customary to plant a cover crop of sour clover on autumn plant fields. This is turned under when cultivation starts in the spring.

In preparing for planting, the fields are laid out in rows 5 to 6 feet apart. A planting furrow is made in the center of this row, not as deep as the bottom of the furrows between the cane rows, in order to allow for drainage. Wagons with the seed cane are driven in the fields and drop the cane in the furrow, usually two running stalks. Boys follow behind with cane knives, place the cane properly in the row, and cut the stalks into shorter lengths so as to have proper contact with the soil. Disc cultivators follow behind and cover the seed several inches deep.

In the spring the cane is off-barred, and excess dirt removed to allow germination. The off-barring incidentally covers most of the sour clover.

Soils and Fertilizers (By G. R. Stewart)

The meeting of the sugar section which dealt with soils and fertilizers was fortunate in having a group of delegates present from many of the important cane sugar countries of the world. The following cane regions had one or more representatives: Australia, Cuba, Fiji, Formosa, India, the Philippines, and Hawaii. A great diversity of conditions and agricultural practice was revealed in these different regions. It may be illuminating to summarize some of the outstanding observations upon sugar cane soils, and their fertilization, in these widely separated districts.

Australia: The principal sugar cane regions are in New South Wales and in Queensland. Both these districts are part of the coastal plains which extend north and south along the shores of the Australian continent for over 1400 miles. The Queensland cane estates lie in the northern section of this coastal belt, and the New South Wales cane land in the southern.

The soils planted to sugar cane show quite a wide variation. They may be divided roughly into the soils of the alluvial flats and the forest soils. The alluvial flats are deep soils which have been deposited along the banks of the rivers. This land was originally covered by a dense growth of tropical scrub. The soils formed under these conditions are inherently very rich.

The forest soils are, in general, lighter in texture than those of the alluvial flats, though occasional areas of clay occur in this forest land. The greatest difference between these two soil types is in productivity. The forest soils are notably poorer in yield than the alluvial flats.

There are also limited areas of true volcanic soils which are very similar to some of the soils of the Hawaiian Islands. In general, the Australian volcanic soils are more porous and open in texture than those found in Hawaii. This volcanic land is extremely deep and is inherently rich soil. In all the Australian cane land, moisture is the greatest limiting factor. This open texture of the volcanic soils, therefore, favors the passage of rainfall far down below the roots of the cane plant, and makes the growth of a crop a very great problem in dry weather.

Very little chemical work has been done upon the Australian soils. Dr. Maxwell made a small beginning in chemical work years ago when he was first in Australia. This work did not continue for any great length of time, though for many years government reports have been issued giving the analyses of the soils from various districts. These analyses were not correlated with any field experiments or attempts to determine the productivity of this land. There are no special problems of soil fertility under investigation in either sugar cane region at the present time.

The fertilizer practice which appears to give the best response in Australia is the use of green leguminous cover crops. The trash is usually burned before cutting the cane, in Queensland, and it is becoming very apparent that this is leading to gradual exhaustion of the organic matter of the soil. The use of green manuring crops has not become universal, but there is strong evidence that it is the best treatment for the cane lands of Australia.

At the present time, it is a fairly general practice to apply about 400 to 600 pounds per acre of a phosphatic fertilizer containing about 5 per cent to 7 per cent of nitrogen and 14 per cent to 16 per cent of phosphoric acid. This fertilizer is put on in the drill at the time of planting. If the ratoons are fertilized, it is customary to apply ammonium sulfate, but most of the fertilizer is applied to the plant crop at the time of planting. This practice is believed to stimulate germination of the cane and force the young growth ahead, so that weeds are more easily controlled. The cane crop in Australia is grown for a period of about twelve months, and the average yield of cane is about 25 long tons, or 28 short tons per acre.

Cuba: In Cuba, practically all the sugar cane lands are formed on a limestone base. There are two general types of soils: the dark red soils, and the heavy, black clay loams. For many years it was believed that cane could only be grown upon the red soils. It has now been proven that the best yields are obtained from the black soils. The red soils are very deficient in humus. Green manuring crops such as velvet beans and cowpeas are now being tried to restore the fertility of the older cultivated red soils.

All the cane soils have an apparently inexhaustible supply of lime. It was formerly believed that all that was necessary to restore the fertility of the sugar cane lands was to allow them to go back into wild growth as forest land. This is a very slow process for building up organic matter in the soil. The use of green cover crops promises to be a much more rapid and effective way to restore fertility.

No extended chemical studies have been carried out on the Cuban soils and no fertilizers are being used at the present time. Nearly all the sugar companies have more land available for cane than is now under cultivation. With this extra land to draw upon, if necessary, and a sugar market which does not warrant a great expansion in production, the tendency in Cuba is to produce cane by the smallest possible outlay. The usual system followed is to cut the cane without firing. The cane tops are used as feed for the bullocks which draw the cane wagons and plow the fields.

The cane trash is allowed to lie in the fields and forms a heavy mulch which effectually prevents weed growth. The plant crop and the first ratoons will ordinarily require considerable cultivation and hoeing. After these two crops have been harvested there is ordinarily sufficient trash to keep down the weeds. The maximum crops obtained are about twenty-five tons of cane per acre. The average crop would probably be from fifteen to twenty tons of cane. The cane fields are ordinarily ratooned for fifteen to twenty years. Fields are not ordinarily replanted till the production of cane has fallen to about eight tons of cane per acre. The crop is grown for about twelve months, all fields being ordinarily cut each year.

Fiji: The best cane lands in Fiji are the alluvial flats, which lie between the low hills bordering the valleys and the rivers flowing through the center of them. A less desirable type of cane land lies further back at the base of the hills, where the soils are partly transported and partly formed of residual material by the weathering of the rocky deposits on the hill slopes. The poorest soils are the upper portions of these slopes, where the land has been subject to excessive washing and erosion.

At the present time, no chemical investigations in soil fertility are under way in Fiji. Many carefully controlled plot experiments have been carried out, comparing local seedlings with standard canes, and contrasting various soil and fertilizer treatments.

As a result of this work, green manure crops have been established as the best fertilizer treatment for the cane lands. On the best lands greater tonnages of cane could be obtained by additional fertilizer applications. The Fiji cane grower has actually found that it is not profitable to raise this maximum crop because of damage which will occur to it before harvest. Badila cane is still the standard variety in Fiji. If a moderate crop of Badila is raised, say about forty tons per acre, the crop will stay erect and will not fall down or lodge before it is cut. With a very heavy crop of Badila, running from 60 to 70 tons per acre, a great deal of the cane will lodge and fall down when rainy or windy weather comes. This results in damage to the stools and breakage and deterioration of the cane. When harvested this heavy crop may have as much as 50 per cent of dead stalks in the field. This has resulted in the policy of raising the maximum profitable crop of about 40 tons per acre, as it actually gives a better return in millable cane and leaves the stools in good condition for ratooning.

For the plant crop, on the rich alluvial lands, it is therefore customary to apply no fertilizer. The medium and poorer lands give a good response to applications of coral sand at the rate of 5 to 10 tons per acre. It is also customary to use about 200 lbs. of sulfate of potash and 300 lbs. superphosphate per acre for the plant crop on these poorer soils.

The ratoons on both good and poor soils receive from 200 to 400 lbs. sulfate of ammonia per acre. The experience, over a number of years, has led the growers to expect an increase of 5 tons of cane per acre for each hundredweight of ammonium sulfate that is applied.

It was formerly customary to save all the trash in order to maintain the content of organic matter in the soil. This also returned an appreciable portion of the potash and phosphates which had been removed by the crop. On account of shortages of labor it has been necessary to abandon this practice on the plant and earlier ratoon crops. The trash is still saved on the last crop harvested before plowing.

As previously noted, the maximum profitable crop for Fiji conditions is about forty long tons per acre. This is commonly obtained from the best land on the plant crop. The plant crop on the poorer lands and the average ratoons will frequently be lower, probably yielding about twenty-five to thirty long tons per acre.

Formosa: The cane soils of Formosa are largely alluvial deposits derived from clay slates and to a smaller degree from sandstone. The resulting soils are in many cases of a heavy clay texture, though loams and clay loams are also found. The soils have nearly all been mapped according to the German system, which was adopted many years ago in Japan.

Considerable chemical work has been done on all the Formosa soils in order to establish any existing relationship between the classification and the composition of the soils.. It is believed this work has developed information of considerable value in planning experimental work upon the fertilization of the cane land.

Extended investigations have been carried out in Formosa upon the reclamation of alkali land. Fortunately, the salts impregnating these soils are largely composed of the sulfates of sodium and magnesium, with smaller amounts of the chlorides of calcium, sodium, and magnesium. It has therefore been possible to reclaim these lands by very simple measures. A combination of drainage and irrigation has now converted some of these former saline areas into some of the most fertile soils in Formosa.

In order to determine the fertilizer requirements of the cane soils, field experiments have been carried on in thirty-four districts where different types of soil are located. In this work the attempt has been made by a study of the yields obtained by all possible fertilizer combinations and the analyses of the plants grown, to try and find the amounts of the different plant foods which the soils are capable of supplying. The general result of this experimental work has been to find that the soils of Formosa are more in need of nitrogen than of phosphoric acid or potash. Some limited areas respond to phosphates, but very little return has been obtained from the application of potash.

One of the first studies undertaken in work upon fertilization in Formosa was the determination of the coefficient of availability of each of the constituents used in the commercial fertilizers. A great deal of work was done along this line and coefficients are now available for each of the commercial materials, when used under Formosan conditions.

The nitrogenous fertilizers most commonly used are ammonium sulfate and soya bean cakes. Some Chile saltpetre has been used, but there is considerable prejudice against its use because of possible loss from the heavy rains.

Green manuring is now considered one of the most valuable practices in Formosa. It has been calculated that a good green manuring crop will supply about 31 pounds of organic nitrogen per acre. It is now a common practice to grow a green cover crop at least once in three years.

It was formerly customary to burn all the cane trash, but latterly the attempt has been made to have the farmers return the trash to the soil. Where this practice has been followed, remarkable improvement has been noted. This is probably due to the great change which is made in the physical condition of the soil by working in the partly decomposed cane leaves. The Formosan soils are generally extremely heavy in texture. The cane ordinarily produces a poor root system in such land. After considerable organic matter is incorporated in this heavy soil, it becomes notably more loose and friable, and the resulting root system is far more extensive.

India: Sugar cane is grown in India upon a considerable variety of soils. The best cane lands are deep alluvial deposits, such as those which occur along the banks of the Ganges River. These soils are sandy loams to silt loams. Around Pusa, cane is grown upon a group of fine silty loams, which frequently may contain as much as 40 per cent of calcium carbonate. Going farther west, there are older alluvial soils which frequently contain undesirable amounts of soluble salts. In central India, there are many areas of heavy clay adobe, upon which cane is being grown.

In general, the soils of India are low in nitrogen and low in organic matter. This is not surprising when one reflects that these soils have been under cultivation for many hundreds of years. There has never been any general use of green manuring crops. Small amounts of cow manure are applied where it is available. A little oil cake has been used in some districts. A few of the more progressive commercial plantations are now purchasing ammonium sulfate. The native cultivators of India work their land to a very shallow depth, stirring the soil for a few inches with a small wooden plow. A field may be plowed in this way as much as ten or twenty times before the crop is finally put in. This is believed to cause considerable nitrogen fixation by azotifying organisms.

The cane yields obtained by these agricultural methods are very low. Exact figures are not readily available, but the yields are probably lower than those obtained in the other important cane sugar countries.

Philippines: There has been more work done on the soils of Negros than any other island of the Philippine group. This island also produces the greater portion of the cane crop. The soils of the western portion of Negros are derived from volcanic lavas, while in the eastern part of the island they have been formed from limestone.

It is only recently that fertilizers have been used in the Philippines. A number of series of experiments have been carried out and all have shown a notable increase from nitrogenous fertilizers. Very little gain has been obtained from either potash or phosphates. The principal nitrogenous fertilizer now employed is ammonium sulfate. Most of the mixed fertilizers which are being applied contain potash and phosphates, as well as nitrogen. These complete mixtures are being put on as crop insurance, in the absence of more extended experiments to show whether potash and phosphates may sometimes be required.

The best yields obtained in Negros will average about one and three-quarter tons of sugar per acre, for a twelve months crop.

Hawaii: The soils of the Hawaiian Islands are almost entirely volcanic. They are derived from a limited group of rocks, the so-called basaltic lavas. The characteristics of these rocks are: a comparatively low content of silica, a high content of iron and aluminum, and a considerable content of calcium and magnesium. The soils formed from these materials have largely been weathered in place and are nearly all residual soils. There are very limited areas of alluvial soils such as are commonly found in the great valleys of the mainland of the United States.

In texture, the Hawaiian soils tend towards the heavier types, loams, silt loams, clay loams, and clays. It should be explained that there are no true clays formed of potassium aluminum silicate, in the Island soils. The clay-like materials consist of the hydrated oxides of iron and aluminum. This gives a light soil of comparatively low specific gravity. The result is a spongy open texture which allows heavy rain to percolate through the soil with ease. There is very little tendency for such a soil to puddle or pack down. We never have any plow sole or hard pan formed in the Island fields.

It was formerly believed that exact deductions as to fertilizer requirements could be drawn from determinations of the plant food present in soils. Later work has shown the great variability of composition which exists in most soils. This has caused many investigators to feel that all such determinations are valueless. With the modern work that has been done in plant nutrition, we have come to feel that the one thing we can draw deductions from is an actual deficiency in any important limiting plant food.

Extensive work has been carried out at the Hawaiian Sugar Planters' Experiment Station upon the soils of the various experimental areas located in the different islands of the group. Part of these soils responded to either potash or phosphate fertilization, and part of them were evidently well supplied with both these constituents. The result of this work was to show that chemical determinations could indicate the soils which were most likely to require potash and phosphate fertilization. Such work is likely to be an excellent basis for the location of carefully planned field trials. The information given by such trials is probably the best basis for fertilizer practice.

Besides work on the composition of typical soils, extensive work has been carried on in Hawaii upon the effect of fertilizers upon the soil. No noticeable increase in alkalinity of the soil or harmful effect from the heavy applications of fertilizers have been detected. Investigations have also been made on the influence of slightly saline irrigation waters.

At the present time, the principal chemical investigation at this Station is a study of the factors underlying the occurrence of root rot. We are studying the relation of occasional accumulations of salt and the occurrence of high acidity to the susceptibility of varieties like Lahaina cane to root troubles.

In considering fertilizers for sugar cane in Hawaii, we may say there is practically always a response to nitrogenous fertilizers. The one exception to this statement is Grove Farm Plantation on Kauai. Owing to the cane area available on this plantation, it is customary to fallow the fields for about three years before replanting. The cover crop used is either the native wild legumes or pigeon peas. On the plant crop following this fallow period, no response is obtained to applications of nitrogen.

The amount of fertilizer used in the different districts in the Hawaiian group varies with the size of the crop that is ordinarily obtained. The field experiments of the Agricultural Department of this Station have helped to establish the profitable limits of fertilization in each section.

A large part of the plantations are using either complete fertilizers or mixtures which include several forms of nitrogen in combination with phosphoric acid. A portion of these plantations are only putting on potash and phosphates as a matter of insurance. We have one definite region which does give a response to potash in addition to nitrogen. This region is along the Hilo coast. Some of the fields at Ewa have shown a response to potash. There have been a few experiments in other districts where there appears to be a response to potash. There is, however, no uniform widespread need of potash.

Experiments with phosphates have shown that there is a need for phosphates on a number of plantations. This is especially true of the upper fields in portions of Kauai, Maui, and Oahu.

The Hawaiian system of heavy fertilization is designed to obtain the maximum sugar production from the limited areas of land available for sugar planting. The Island soils appear well adapted to this agricultural practice. It may also be stated conservatively that there is no present evidence of any decrease in productivity from continuous cropping to sugar cane.