TABLE OF CONTENTS;

Sugar Plantations, Cane Growers and Sugar Mills.

ISLAND AND NAME.		MANAGER.	POST OFFICE.
OAHU.			
Apokaa Sugar Co.	*	G. F. Renton	Ewa
Ewa Plantation Co.	*	G. F. Renton	Ewa
Waianae Co.	***	Fred Meyer	Waianae
Waialua Agricultural Co.	*	W. W. Goodale	*Waialua*
Kahuku Plantation Co.	x*	Andrew Adams	Kahuku
Waimanalo Sugar Co.	**	G. Chalmers.	Waimanalo
Oahu Sugar Co.	x	E. K. Bull	Waipahu
Honolulu Plantation Co.	**	J. A. Low	Aiea
Laie Plantation	x*	S. E. Wooley	Laie
MAUI.			
Olowalu Co.	**	Geo. Gibb	Lahaina
Pioneer Mill Co.	x	L. Barkhausen	Lahaina
Wailuku Sugar Co.	**x	C. B. Wells	Wailuku
Hawaiian Commercial & Sug. Co.	x*	H. P. Baldwin	Puunene
Maui Agricultural Co		H. A. Baldwin	Paia
Kipahulu Sugar Co.	x	A. Gross	Kipahulu
Kihei Plantation Co.	x*	James Scott	Kihei
HAWAII.			
Paauhau Sugar Plantation Co.	**	Jas. Gibb	Hamakua
Hamakua Mill Co.	*x	A. Lidgate	Paaullo
Kukaiau Plantation	x	J. M. Horner	Kukaiau
Kukaiau Mill Co.	*x	E. Madden	Paaullo
Ookala Sugar Co.	**x	W. G. Walker	Ookala
Laupahoehoe Sugar Co.	*x	C. McLennan	Papaaloa
Hakalau Plantation	*	J. M. Ross	Hakalau
Honomu Sugar Co.	**x	Wm. Pullar	Honomu
Pepeekeo Sugar Co.	**x	Jas. Webster	Pepeekeo
Onomea Sugar Co.	**x	J. T. Moir	Hilo
Hilo Sugar Co.	**	J. A. Scott	Hilo
Hawaii Mill Co.	x	W. H. Campbell	Hilo
Waiakea Mill Co.	*x	C. C. Kennedy	Hilo
Hawaiian Agricultural Co.	**x	Wm. G. Ogg	Pahala
Hutchinson Sugar Plantation Co.	**	Carl Wolters	Naalehu
Union Mill Co.	*x	H. H. Renton	Kohala
Kohala Sugar Co.	*	E. E. Olding	Kohala
Pacific Sugar Mill	x**	D. Forbes	Kukuihaele
Honokaa Sugar Co.	x**	K. S. Gjerdrum	Honokaa
Olaa Sugar Co.	xx	J. Watt	Olaa
Puna Sugar Co.			Kapoho
Halawa Plantation	x*x	T. S. Kay	Kohala
Hawi Mill & Plantation	††	John Hind	Kohala
Puako Plantation	††	Jno. C. Searle	S. Kohala
Niulii Sugar Mill and Plantation	*x	Robt Hall	Kohala
Puakea Plantation	*x	H. R. Bryant	Kohala
KAUAI.			
Kilauea Sugar Plantation Co.	**	Frank Scott	Kilauea
Gay & Robinson	x*x	Gay & Robinson	Makaweli
Makee Sugar Co.	----	G. H. Fairchild	Kealia
Grove Farm Plantation	x	Ed. Broadbent	Lihue
Lihue Plantation Co.	x	F. Weber	Lihue
Koloa Sugar Co.	x	P. McLane	Koloa
McBryde Sugar Co.	*x	W. Stodart	Eleele
Hawaiian Sugar Co.	x*	B. D. Baldwin	Makaweli
Waimea Sugar Mill Co.	*	J. Fassoth	Waimea
Kekaha Sugar Co.	x	H. P. Faye	Kekaha

KEY.

HONOLULU AGENTS.

	Castle & Cooke	( )
**	W. G. Irwin & Co.	(8)
***	J. M. Dowsett	(1)
x	H. Hackfeld & Co.	(9)
*x	T. H. Davies & Co.	(8)
**x	C. Brewer & Co.	(6)
x*	Alexander & Baldwin	(6)
x**	E. A. Schaefer & Co.	(2)
x*x	H. Waterhouse Trust Co.	(2)
††	Hind, Rolph & Co.	(2)
xx	Bishop & Co.	(1)

THE HAWAIIAN PLANTERS' MONTHLY

PUBLISHED FOR THE

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

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SUGAR PRICES FOR MONTH ENDING APRIL 12, 1907

	Centrifugals.	Beets.
March 15	3.50c.	8s. 11¼d.
March 22	3.5325c.	9s. 3d.
March 29	3.61c.	9s. 3d.
April 5	3.61c.	9s. 2¼d.
April 12	3.722c.	9s. 3¾d.

Czarinkow, Macdougall & Co., in their report of April 19 state:

Our last report was dated 12th April.

This week's official figures of Centrals grinding in Cuba were awaited with unusual interest. When they came they showed a falling off even greater than had been expected, the number reported at work being 134 as against 162 last week, a decrease that fully confirmed previous pessimistic reports as to crop conditions in many districts.

So far, this further diminution in the sugar production of our main source of supply has had little effect upon this market. It brought some of the outside refiners in as buyers, but this demand was quickly supplied, and a full response to the increasingly favorable market conditions must await the time, which cannot be far distant, when general buying on a large scale must take place.

One thing that, doubtless, has something to do with the present attitude of buyers is the large receipts at the Atlantic ports. These reached 57,620 tons this week and, naturally, weighed upon a market where melting requirements are only 39,000 tons. Nor are the prospects for the coming week any better, for this week's exports from Cuba are heavy and the effect of this will be felt in our next week's receipts.

Last season it was until late in May that the number of Cuban Centrals at work was as low as it was on the 16th inst.

(May 25th, 1906, 141; June 1st, 97), and it is, therefore, interesting to note that, as can be seen by reference to the figures given in our last report, the Cuban production between the end of May, 1906, and the winding up of the crop was only 123,000 tons. On this basis, and taking this season's production since 1st April as 100,000 tons, we get 223,000 tons to add to the 1.017,192 tons produced up to 31st March, and a total crop of 1,240,193 tons. It must, however, be borne in mind that last year the number of Centrals grinding was reduced to six by June 22d, or three weeks after the time with which we are comparing the present season. That a similar reduction will take place in the coming three weeks is hardly to be expected, for that would mean that the crop would be practically at an end by 10th May or six weeks earlier than last year. All that the comparison shows is that a crop of 1,250,000 tons is assured and that one of more than 1,350,000 tons cannot be reckoned upon.

The preliminary estimates of beet sowings were announced on 17th inst. and gave an increase of 2½ per cent. for all Europe. On the basis of the 1906-7 crop of 6,700,000 tons, the increase in acreage would be equal to an increase of 134,000 tons sugar, but it must be remembered that weather conditions were especially favorable for the 1906-7 crop, and the present increase in sowings may be more than neutralized by different weather conditions this year.

Messrs. Willett & Gray in their Weekly Statistical of April 18 say:

RAWS.—The influence of the rapid curtailment of the manufacture of the Cuba sugar crop has a marked beneficial effect on the sugar consuming markets of the world and more especially upon the speculative exchange markets of Europe.

Following the first rise in beet sugars under this influence, there has been during the week under review a further advance from 9s. 3d. to 9s. 5¼d. (parity of 3.98c. per lb. for Centrifugals), which advance is fully maintained at the close, as well as an advance of 3d. per cwt. in cane sugar. Locally the market has been strong and active, the activity being somewhat limited by reduced offerings, the pretentions of holders being directed to advancing prices to the parity of Beet sugar quotations before selling freely.

Spot Centrifugals closed last week at 3.735c. per lb. duty paid for 96 deg. test basis, and this week advanced to 3.765c., while for last half May shipment 1-32c. per lb. advance has been paid and now quoted firm at 2 7-16c. c. & f. 96 deg. basis (3.80c.).

Nothing has been done in June shipments which are sparingly offered at 2½c. per lb. c. & f. 95 deg. test basis, equal to 3.89c. landed for 96 deg. test.

Last week the indications were that the European Beet sowings would be increased 5 per cent., but now Mr. F. O. Licht, European beet crop expert, estimates an increase in sowings of only 2½ per cent., which is favorable to market values.

Taken in connection with the present indications for the cane crop of Cuba, these notable features have a bearing for good upon the course of prices for some time to come, which will be especially profitable to the domestic cane and beet sugar industries of the United States.

In Cuba 134 Centrals are working with receipts of 37,000 tons for the week against 183 Centrals at highest point with 65,000 tons weekly receipts.

The visible crop now is 1,110,000 tons, leaving 140,000 tons to be reported to reach our minimum estimate of 1,250,000 tons. Another week's report will probably give a basis for a maximum crop estimate.

The tone and tendency at the close are to continued firmness, with gradually improving tendency.

NOTES.

REVISTA AZUCARERA.—We are in receipt of the *Hacendado Mexicanos* yearly sugar report for 1906-1907 under the above title. The report is illustrated with views of many of the important sugar factories of Mexico and contains valuable statistics relating to the sugar industry of Mexico.

It is reportetd that the cane crop of Mexico for this year is above the average in quantity and of good quality and that upon the whole the expectation is for a good year in the sugar industry.

AGRICULTURE PROGRESS IN PHILIPPINES.—A recent bulletin of the Board of Agriculture of the Philippine Islands states that a 35-horse-power steam plow is now in operation on the sugar lands of the Santa Rosa Friar Estate. This plow was sent there in response to a resolution of the Philippine Commission for lease to the sugar planters who desired to reclaim lands which had not been cultivated for many years.

Many difficulties have been experienced with the plows in use on account of the very rough nature of the land. A satisfactory plow has now been perfected.

Another smaller engine will be sent up in a few days and there is abundant work to keep both of them busy until the rainy season sets in.

By this arrangement it is hoped to place much of the land which has lain idle so long on this estate into cultivation and profitable production.

The Bureau of Agriculture established nine districts in the Philippines including all provinces and important islands.

The object in forming these districts is to better define the work of this Bureau in the several lines of investigation and control over which it has supervision, and to establish a definite point in each district to which all urgent reports may be made and acted upon promptly. There are to be stationed in every district one or more veterinarians or agricultural inspectors whose duties will be to keep thoroughly posted on all matters pertaining to general agricultural and animal industry in their districts, make crop reports, distribute seeds, collect native plants and seeds that promise to be of value, give information of general interest on agricultural subjects, locate outbreaks of animal diseases and place the same under control, investigate crop pests (such as blights and locusts), and take such other steps as may be necessary for bettering agricultural conditions. They will act as general agents for the Bureau in the provinces.

The veterinarians will be in charge of all questions pertaining to animal industry and infectious diseases of animals, such as rinder-pest, surra, etc.

The agricultural inspectors and assistant inspectors will take the place of the inoculators transferred from the Bureau of Health with the veterinary division, November 1, 1905.

The inspectors are men thoroughly trained in the agricultural colleges and schools of the United States, and their reports and observations on general agriculture will be of great value to the Bureau and the whole Islands.

The assistant agricultural inspectors, at the beginning, will be of similar qualifications as the present inoculators, and will in a general way assist the veterinarians and inspectors.

It is also hoped that the heartiest coöperation can be secured from the other Government officials in these districts, especially the governors of the provinces, presidents of municipalities, superintendents of education, and district health officers.

PARASITES OF LEAF HOPPERS.—Under the above title the Division of Entomology of the Experiment Station of the Hawaiian Sugar Planters' Association has issued a bulletin dealing with parasites and leaf hoppers collected and studied by Mr. Koebele in Arizona.

In the summer of 1905 Mr. Koebele visited Germany on a vacation trip and collected a considerable amount of European material which has been of great service to the Entomologists

in working out the American species and enabled them to correct a number of errors in former papers.

In addition to these consignments material received from China collected by Mr. Muir of the Station has also been carefully examined and studied. To any one who has followed the work done by the Entomologists relating to leafhoppers and their parasites it will be evident that the work, both in the field and study, has been of a very extensive character, and it is now possible to come to a very extensive character, and it is now possible to come to some general conclusions as to what enemies keep the countless species of leafhoppers—all of which are potentially injurious—in check, throughout a large part of the world. One is at once struck with the fact that whether in Europe, Asia, Australia or America, the parasites or predators that destroy leaf-hoppers in each country belong mostly to the same groups.

Dr. Perkins, author of the Bulletin, says: "Egg parasites are everywhere present. *Anargrus* of the Mymaridae attacks the eggs of the Delphacidae alike in Europe, America, Australia, Fiji and China, and even the species hardly differ in these countries; while *Paranagrus* has been found in Fiji, Australia and China, and *Ootetrastichus* of the Chalcid flies in the same countries.

"Other Mymarids of several genera attack the Jassid hoppers, some of which are also periodically decimated by the excessive minute Chalcids of the family Trichogrammidae, both in America and Australia. These latter likewise destroy the eggs of the allied Membracidae. Such Fulgorids as lay their eggs on the surface of plants have different egg-parasites. In Australia they are attacked by Proctotrupids, and also by Encyrtidae of the Chalcid group, but in other countries their enemies have not been investigated. A foremost place amongst beneficial insects must be assigned to all these egg-parasites, as by destroying the egg they kill the hopper before it arrives at a stage when it can do injury. Of the other Hymenoptera, Dryinidae are no doubt ubiquitous throughout the world, and they attack many species of hoppers both in the Fulgorid and Jassid groups, and have also been reported as attacking Membracids. Cercopidae are, so far as is known, not attacked by them, but the young of these are, as is well known to every field worker, a favorite prey of various Fossorial Hymenoptera, e. g. *Harpactus* and *Gorytes*. The Fosors likewise yield species that prey on Jassids; amongst the minute Crabronidae, for instance, we have found the cells of the European *Crossocerus gonager* Lep. filled with a species of *Typhlocyba* that infests beech trees. In these islands, one may see a Mimesid (*Nesomimesa hawaiiensis*) hawking for various species of fulgorid leaf-hoppers, but these are not its usual prey, which consists of certain Limnobiine

Diptera. It is interesting to note that its attempt to seize the Fulgorids is usually a failure. As all the other known Hawaiian species of *Nesomimesa* prey on the Diptera mentioned, it would appear as if it were comparatively recently turning its attention to the Homoptera. The singular head structure of the female wasp probably aids it in some way in capturing the flies, while ineffective for holding the other prey. The Dipterous Pipunculidae are also ubiquitous, and attack both Jassids and Fulgorids of various groups, alike. On the whole they appear to chiefly parasitize Jassids, but the Hawaiian species, so far as is known, are all parasitic on Fulgorids, in fact on Delphacids only.

The Stylopidae parasitize very diverse groups both in the Jassid and Fulgorid series. The little *Elenchus* seems to attack the Delphacidae in all localities, where these have been specially examined, and the specific characters of these parasites seem to be almost if not quite identical in widely separated countries; at least there is very little if any real difference between *Elenchus tenuicornis* of Europe and the examples found in Australia, Viti, and North America, that I refer to it. It is proper to state in this connection that one of the species of *Liburnia* attacked by *Elenchus* is found to be itself common to both Australia and North America and it would not be surprising to find that it also inhabits Europe, where, in any case, there are very closely allied species.

The Chalcids seem rarely to attack hoppers, after they leave the egg, but in Australia are two fine species of Encyrtidae, *Meniscocephalus eximius* and *Neocladia howardi*, which are bred from nymphs or adults of a Jassid (*Eurinoscopus*), and recently Mr. Muir has bred the latter parasite from quite another Jassid in China. Recently from a Jassid nymph in Arizona Mr. Koebele bred another distinct form of Encyrtid, described in this bulletin under the name *Thysanomastix Koebelei*. This species differs in habits from the others above mentioned, in the fact that several of the parasites emerged from a single host, and it is remarkable that the latter (*Oncometopia lateralis*) survived its injuries for several days after their emergence, when one considers the size of the parasites.

Of predacious insects it may be noticed in passing that the larvae of various Malachiid beetles, both in America and Europe, destroy the Delphacid hoppers that live on grasses, and some of them appear to be very voracious, so that on one occasion, Mr. Koebele had many parasitized leaf-hoppers destroyed by these beetle larvae, accidentally included in his breeding jars.

Of the parasites enumerated in this Bulletin, it was not attempted to introduce any into the Hawaiian Islands, excepting the minute egg-parasite, *Trichogramma helocharae*. An

attempt was made to breed this on the eggs of *Perkinsiella*, but, as Mr. Koebele and myself had expected, without success. I was, however, able to establish it at large on the eggs of a common introduced Jassid, and have, since it was liberated some six or nine months ago, frequently met with it. The fact that Jassid leaf-hoppers abound in cane fields of other countries whence cane has frequently been imported into these islands, while in the event of any of these showing up here, we have practically no natural enemies which would destroy them, made it worth while to establish the *Trichogramma* here. It is a very effective enemy of its proper host, for though I bred scores of the parasites from the leaf-hopper eggs sent here from California, not one single leaf-hopper emerged, and Mr. Koebele had just the same experience in that State.

REPORT OF THE LOUISIANA SUGAR EXPERIMENT STATION, 1906.

We are in receipt of the Nineteenth Annual Report of the Agricultural Experiment Station of the Louisiana State University, and the following relating to sugar experiments is of interest.

Mr. R. E. Blouin has remained in active charge of the work of this station, and has very ably administered its affairs and conducted the experiments in field and laboratory in a thoroughly scientific and practical way. The field of investigation has been somewhat enlarged, and very valuable results have been obtained, both from a technical and a practical standpoint.

The year 1906 has been a bad year for the sugar interests of the State. The spring was cold and wet, and stubble cane suffered severely throughout the State. When warm weather came it was accompanied by drouth, which in turn was detrimental to the growth of the cane crop. Accordingly the yields throughout the State were poor, much below the average, both in tonnage and sugar content. The crop at the station was well up to the average in tonnage, but was deficient in sugar content.

IRRIGATION.

The tonnage secured again emphasizes the necessity of thorough preparation of the land in the fall and the value of irrigation. Irrigation was resorted to twice, on May 29 and June 20, and is to a large extent responsible for the good tonnage secured. The plats comparing irrigation and non-irrigation canes were in second year's stubble this year, and owing to imperfections in the stand of cane, cannot be strictly com-

pared; however, the results show a marked improvement in the cane by irrigation.

FERTILIZATION AND CULTIVATION.

The study of the fertilizer requirements of D 74 has been continued and new experiments added, and the results are now showing good promise, though it will require some time before positive results can be secured.

We also started fertilizer experiments on succession cane and various combinations on the home varieties. With cultivation experiments our results show markedly the advantage of frequent and shallow cultivation. To this we have added one new implement this year which is still in its experimental stage, though giving promise of good results. This is the ordinary harrow with a bull-tongue in the center, making a clean sweep of the middle of the rows, using a disc and bull-tongue for our middles instead of the shovels now so popular in the State. Experiments with new implements in the preparation of the land have also been inaugurated, breaking land at different depths and in a different manner, and we are testing the deepest possible breaking of the land in Louisiana. We look forward to some very interesting results from these experiments. They are conducted upon both sandy and stiff lands.

SEEDLING CANES.

The D. 74 and D. 95 seedling canes have again maintained their superiority over the home canes, not only on the station, but throughout the State, the result being a large extension of the area planted in these canes this year. This applies particularly to the D. 74, which is highly commended by practically all planters. An extended report was made to the Sugar Planters' Association and published in the Louisiana Planter and Sugar Manufacturer, (and will later be published in bulletin form) on the results from these two seedlings compared with home canes during this year, which was favorable in every instance to the new canes, both from a field and sugar house standpoint. At the station here the D. 74 showed itself markedly superior to either the home or D. 95, the tonnage being greater and the sugar content very much greater than the home cane, and markedly greater than the D. 95, also being richer in sugar than the home cane.

New seedling varieties were introduced this year from Jamaica, Java and Barbados, and they have now been placed in our regular variety plats to compare them with other canes. We have also secured from the Hawaiian Islands a quantity of cane seed, and have for the first time successfully germi-

nated these seed in Louisiana, and we have now Louisiana seedlings which are ready to be placed in the field. In December we received another consignment of cane seed from the Hawaiian Islands. These have been planted and have germinated remarkably well, and we have every hope from this germination to secure a number of seedlings from these plantings. There are prospects that some of these will develop into very desirable canes for Louisiana.

SUGAR HOUSE WORK.

In the sugar house we continued our experiments comparing the home and seedling canes from a sugar manufacturing standpoint, and investigated carefully the amount of clarifying agents left in our products during manufacture. This is particularly of interest now, owing to the Pure Food Law being in operation, and these experiments were conducted in order to post ourselves in advance as to the composition of these products.

LABORATORY WORK.

The laboratory has been investigating the composition of molasses, and the effects of the different agents in clarification upon this molasses and the amounts of these agents remaining in it. This entailed an immense amount of analytical work, which is not yet completed. The results are very interesting, and will have value in relation to the application of the new Pure Food Law to our cane industry.

A study of the effects of the different fertilizing ingredients on the composition of cane has not been quite completed, and this work will be continued.

Dr. C. A. Browne, our efficient chief chemist, resigned to accept a position in the sugar laboratory of the Bureau of Chemistry, Department of Agriculture at Washington, much to our regret, as his services had shown him to be an extremely able and efficient worker. His place has been filled by Dr. Fritz Zerban, who was Carnegie Research Chemist at the college of the city of New York.

CANE LOADERS.

We had two trials of cane loaders this year. The object of the demonstration was to exhibit the different models and bring before the planters the improvements that had been made in these machines. At the first trial, held May 9, there was a very fair attendance, with only two machines on trial. These were the Moline and Guassiran cane loaders. At the second trial there were present the following loaders: Moline,

Luce, Castegnos, Landry and Mire. These five loaders were given a thorough trial in exhibiting their respective merits, and this trial was the most successful one ever conducted on the station. There were over three hundred planters in attendance from every part of the State, and they were given an excellent opportunity of viewing the working of the different loading devices.

CANE HARVESTERS.

We have continued testing cane harvesters here, several tests being made, and it is gratifying to note that there is some improvement in these machines. The number of patentees of these devices are increasing, and some of them are at work in this State. The outlook is very hopeful for success in this line, and when this has been accomplished it will be a great relief to the sugar planters in the labor problem. The D. 74 cane is considered extremely desirable by the cane harvester men, the majority of them making their harvesters to handle only this cane. This is due to its erectness under all conditions, giving us straight cane to be handled by the harvester.

IMPROVED IMPLEMENTS.

This station has tried a number of new agricultural implements this year and discussed with the various manufacturers alterations pertaining to them. All manufacturers, agents and inventors are invited to test their implements here, and we are glad to encourage such tests, and visitors to the station are welcome to witness them.

SUGAR SCHOOL.

The demand for graduates of the Audubon Park Sugar School of the Louisiana State University and Agricultural and Mechanical College has increased this year, and we are unable to supply the demand from sugar countries that come to us for such graduates. While the students are down here they are given practical work in agriculture, chemistry and sugar house work.

SUGAR CANE DISEASES.

A fungus has been found generally present in cane fields of some sections of the State, and indications lead to the suspicion that this fungus plays a part in bringing about a diseased yield, especially of stubble cane. Experiments to determine the exact role of this fungus are now being carried on.

SUGAR INDUSTRY IN THE LEEWARD ISLANDS.

The following is extracted from the Annual Colonial Report on the Leeward Islands for 1905-6:

This constitutes the principal industry of Antigua and St. Kitt's; in Nevis and Montserrat the industry is in a decadent condition. In Antigua, owing to drought, the crop was small; St. Kitt's was not, however, so severely affected. The average annual export of sugar of Antigua and St. Kitt's is about the same.

In Antigua the central factories at Gunthorpe's and Bendal's have continued operations. These institutions are bound by the contract under which they received Imperial grants to assist in their construction, to purchase, if tendered, peasants' canes to the amount of 1500 tons per annum in the case of Bendal's and 4,000 tons per annum in the case of Gunthorpe's. The prices paid vary on a sliding scale with the market price of grey crystal sugar, and in no case can it fall below 7s. 6d. per ton of cane. The effect of this has been considerably to increase the area cultivated by peasant farmers.

Experimental cultivation of sugar cane has been continued under the auspices of the Imperial Department of Agriculture in Antigua and St. Kitt's. The object of these experiments is to ascertain, by cultivation of a number of varieties of seedling canes, which canes are most likely to produce increases in the yield of sugar per acre, and at the same time are most resistant to disease. The effect of these experiments has been to eradicate cane disease in the Leeward Islands to a large extent. Manurial experiments are also conducted with a view to ascertain the manurial requirements of the sugar cane. In all there are ten sugar experiment stations in Antigua, and nine in St. Kitt's; the results obtained are followed with keen interest by planters.

THE CULTIVATION OF SUGAR IN INDIA.

(From Tropical Life.)

Following on the paper read by Mr. Venkoba Row before the South Indian Association and referred to in our November leader, Mr. Rajarabua Mudaliar, C. I. E., also spoke on the possibilities of improving the Indian sugar industry, and the Indian Review for October published the paper in extenso.

Both the authorities quoted agree that improved methods of cultivation and improved systems of manufacture are absolutely necessary if the sugar industry of India is to be placed on a remunerative basis, and it is furthermore suggested that the government might assist in several ways to attain this end, as, for instance:

(1) By improved agricultural and technical education.
(2) By appointing more agricultural chemists.
(3) By controlling the sale of fertilizers.
(4) By developing agricultural banks on wider lines.
(5) By improvements in the working of the Loans Acts.

These reforms, if brought about, would greatly benefit the industry, and those anxious to see the sugar industry in the West Indies placed on a more popular and self-supporting basis should carefully study the points raised in Mr. Mudaliar's paper.

The hereditary instinct and centuries' old experience of the Indian ryot that causes him to know better than his critics what will pay him best and naturally makes him feel averse to putting his hand to new ventures until he can foresee that the results will be to his advantage, proves the necessity for introducing ocular demonstration in order to get the ryot to adopt more up-to-date methods than those at present in use. The marvel has been that so primitive a class of cultivator has done so well without any technical knowledge or scientific training. Far from the lazy, ignorant and improvident cultivator that it is more or less the fashion to describe the ryot as being, he is open to conviction, and if shown by practical demonstraton that a better return can be extracted from his land he will at once change his methods. This is proved by Rao Mudaliar of Bellary. Now, reports Mr. Rajarabua Mudaliar, there are about 1,500 Swedish plows in use in the districts round Bellary.

The local government seems to have made some attempt to remedy the lack of technical knowledge by the establishment of experimental farms, but though they have cost money, they often stopped short when most wanted. Now it is hoped an improved system, covering the ground more thoroughly, will be initiated by the head government. One step in the right direction, an important one, was the laying of the foundation stone by Sir Arthur Lawley on September 24, 1906, of the new Agricultural Institute at Coimbatore, whilst two sugar cane farms are being maintained by local governments in Godavari and South Arcot.

Water engineers would do well to study the needs of improved well-sinking and irrigating systems that must be carried out before the area under cane can be extended, or the yield either of the canes themselves or the juice in the cane

increased. Makers of oil engines should find a good outlet for their plants to work water supplies for irrigation purposes, judging by the success achieved by Mr. Panduranga Mudaliar in this way. This planter first sunk a 20-foot well to a depth of 30 feet and installed a 6-horsepower oil engine. Finding the supply insufficient, he sunk a 7-inch tube to a further depth of 50 feet, when he came upon an excellent sub-artesian spring, which now gives full work to a 9 horsepower oil engine, and is capable of irrigating 40 to 50 acres of land at a total cost of about 2,500 rupees. Where the holdings are small it is suggested that several landholders could join together and purchase a plant between them.

Simultaneously with the improvement of irrigation facilities in the manner described, efforts must also be directed to the establishment of up-to-date sugar factories, for without their aid the cane-growing industry to which the ryot must look to for a living, can never prosper, and where outside capital or credit is not obtainable the local concerns must coöperate and raise the capital among themselves. This can also be done in other parts of the empire, as Fiji and the West Indies, with advantage both to the smaller planters who grow the canes and the sugar engineers who supply the plant. Agricultural banks on the principle of the well-known Egyptian bank, introduced by Lord Cromer, or the establishment of coöperative credit societies on the system in vogue in Europe, as mentioned by Mr. Edwin Pratt in his "Organization of Agriculture," would also go a long way to solve the financial difficulty with sugar cane cultivation both in the East and the West Indies. The West Indies especially are very far behind in this respect, though in their case want of stability in the Creole character has a good deal to do with their difficulty in getting such ventures on a popular basis financed from here. In the case of the Indian ryot, however, this is a fault that cannot be urged against them; we hope with the spread of education among all classes, both at home and in India, and the colonies that we shall hear less of these backward and neglected industries. If less money were wasted in financing bogus concerns where everyone hopes to grow rich without working and devoted to honestly worked concerns, capable of giving a fair return when properly studied by the investor, we should hear little or nothing of famines and the backward state of the sugar industry in India, or the scarcity of real cane sugar to sell against beet sugar at home, for if the West Indies cannot produce sugar as cheaply as Europe can, the East Indies, provided with the latest systems of irrigation and the best machinery, certainly ought to be able to.

ANSWER OF MR. A. W. KEECH TO CRITICISMS ON HIS PAPER ON MILL SETTINGS AND MILLING, READ BEFORE THE HAWAIIAN ENGINEERING ASSOCIATION AT ITS APRIL, 1907, MEETING.

I am very much opposed to controversy, from the definition of the word, which means to turn against. For that reason I did not make answer to the three critics on mill settings of last year. The full and free discussion of pertinent subjects is necessary to the general welfare of social human beings. Discussion was, and is, the embryo parliament of the family, as the family was and is the first plural and social unit of society. I advocate the fullest and freest discussion—the frankest expression of opinion as a safety valve for the thoughts and emotions that arise as a natural consequence of our humanity. I made certain statements then, which the critics justly said were incomplete, which is true. Those gentlemen were very kind and fair, even plausible, though I cannot admit that they were altogether correct. I must congratulate the Association on being able to produce such critics, even though I do not admit their conclusions as correct. My sole desire was to give some basis on which to build a system. Some of the criticism was such as I would have made had the subject been that of another person. In giving my ideas, I was not looking for glory—for there is nothing in it.

The system of mill settings worked well at Honomu under conditions variable to some extent. Honomu has to all intents and purposes a modern nine roll mill—the first nine roll mill turned out by the Honolulu Iron Works. It is an example of good workmanship, and can be kept the equal in efficiency of the new nine roll mills. I feel certain that the differences in design and operation of our modern mills is not greater than exists among the members of the horse family. Now, a system of veterinary medicine has been successfully evolved which is a system of standard medicines and standard doses, to be varied from, by and through the experience of the practitioner. This same system treats the draught mule as well as the race horse with success. I have taken this illustration of doctoring dumb animals, for I regard a sugar mill as a dumb thing of cast iron dumbness. The horse tribe are practically brainless for domestic purposes, and in that condition their usefulness depends on the brain of the driver. The sugar mill has no brain, and had it no more than horse brains it could but grunt and groan, as it now does, and feel pain to boot. Its success is in the brain of its driver; its health is in the hands of its doctor; and the engineer

Mr. Keech's paper, Mill Settings and Milling, was read before the Association at its May, 1906, meeting.

is both driver and doctor. I am sure it is possible to evolve a system of mill practice just as it has been possible to evolve horse doctoring.

I will now complete my paper by adding the following:

This is what they complain of—the ratios. This is from the Honomu blue print that was made at the time the mill was put up. Rolls 32″ diameter and 60″ length. Fifty-two R. P. M. of the engine gives 2.23 R. P. M. of the first mill. That gives 18′ 8-18/100″. The second mill is 2.48 R. P. M., which gives 20′ 9-31/100″. The third mill is 2.73 R. P. M., which gives 22′ 10-44/100″. This gives you the relative speeds; but we ran engine 45 R. P. M. at times, and also 42 R. P. M. Then this would stall; it would not change the relative speed, of course; but it would change the surface speed, and you can form from that the ratios. Now, the only thing I want to add. With the mill settings I give, if they are practicable at all, they can be put into operation by allowing for the changes in speeds. If the second mill revolves faster than the first mill, you have to give a smaller opening to the second mill.

These are the relative speeds from which the deductions were made. Any variation from these ratios requires an inverse change in the mill opening following. I have an idea that this mill openings question can be wiped out by making the three roll combination entirely flexible, as I shall endeavor to show on the blackboard.

I have lately seen a ring housing. It is new to me. I know nothing about the man that got it up. But he has a ring-housing instead of having a housing that we have here; but I do not see any advantage about that.

We will take the first mill at Honomu. We have 3/4 opening for feed roll, and we have 1/4 opening for discharge roll. You have a proportion continually here. It starts from 3/4 to 1/4, and that is what gives rise to this discussion about giving the proper openings, so that you will have proper crushing in this combination. The main thing that we are looking for as far as I can see is, to have the blanket squeezed at six places. We want to know what is taking place there, and that gives rise to these discussions about mill openings. They put jacks on the top, or on the bottom. A jack gives a certain pressure, and that pressure is divided between the two bottom rolls. If the opening is too close on one of the bottom rolls, that releases the other roll. The top roll is, of course, simply an opposable roll as the thumb is to the fingers.

If you add another jack to a ring housing, it is possible to reach flexibility. With a suitable hydraulic arrangement, it can be made flexible. We will say for argument that we have 160 tons on one roll and 80 on the other. This does just what two

men do in carrying a weight between them—it shifts to one man, and the other does not do anything. If we give a hydraulic of half the area of a 10″ diameter jack, say seven, for the discharge roll, we have a flexible combination such that we can say that we have 80 tons on each bottom roll, the two places are pinched at 80 tons. You can set this combination, and when the feed comes in here and the top roll rises off, you have 80 tons continually at both places, so that you can predict when you walk into a mill that the pressures are efficiently applied. A full area jack on top roll, an half area jack on discharge roll in line of centers, will make a flexible combination. I believe that it would be possible and would be practical and would work out practicably well to have a half area jack as indicated. It would do away with all the discussions.

By Mr. Pratt—In figuring the area of the smaller jacks you must remember you have the weight of the lower roll working against the jacks; whereas the upper rolls is working against the jacks.

By Mr. Keech—We would hand that over to the chief draughtsman, and he would do all that.

It would in this way make the whole system flexible if you make two rolls flexible.

,Mr. Mr. Nicholai—You can make one roll flexible to all three of them.

By Mr. Keech—That is what we want. If you can make two do the work of three, that is what we want.

By Mr. Nicholai—It would be more expensive than to have two jacks.

By Mr. Keech—The point I am after is to control the squeeze at six places along the line, to make conditions such so that you can predict that at six places in a nine roll mill you can control the squeeze at those places. I believe myself that you cannot make a hard and fast rule for it in a semi-flexible mill. If I have conveyed that idea, it is wrong.

By Mr. Ballentyne—I think that is the idea that some did have.

By Mr. Keech—They are wrong; my system is something simply to vary from. Mr. Ramsay said a standard made to vary from is no standard at all.

*THE IMPROVEMENT OF THE SUGAR CANE BY SELECTION AND HYBRIDIZATION.**

By Sir Daniel Morris, K.C.M.G., M.A., D.C.L., D.Sc., F.L.S., V.M.H.

Imperial Commissioner of Agriculture for the West Indies.

and

F. A. Stockale, B. A. (Cantab.)

Mycologist and Lecturer in Agriculture on the Staff of the Imperial Department of Agriculture for the West Indies.

(Continued from March Number.)

OUTLINES FOR FUTURE WORK.

Formerly, with a nearly common standard of perfection, the attempts to procure an improved race of sugar canes centered around breeding from the best varieties; but now, by carefully analyzing the different characters of the different varieties under cultivation, it may be possible to breed methodically for definite objects.

The work on inheritance carried out by Mendel and communicated to the Brunn Society in 1865, and since so ably elucidated by Bateson, shows conclusively that the gametes are pure with respect to the characters they carry. Further, the work of Biffen with wheat breeding should serve as a model on which breeding of sugar canes should be carried on. By following such methods, instead making a considerable number of crosses indiscriminately with the hope of obtaining some improvements, hybridization on definite lines should now be carried out.

The first thing to consider, therefore, is what desirable characters are required to be chosen. As it is necessary that the hybrids should be an improvement commercially, only those characteristics of the cane which appeal to the planter should be considered. The chief amongst these are:

(1) Behavior under extreme conditions of drought or excessive moisture.
(2) Maturity—whether early or late.
(3) Disease-resisting power.
(4) Milling qualities.
(5) Tonnage of canes per acre.
(6) Richness of juice in saccharose.
(7) Purity of juice.

It would be impossible at the outset to consider all these characters and, consequently, it would be advisable to work with those which are of greatest value economically.

The essential characters to be considered are resistance to drought, resistance to disease, a larger tonnage of cane per acre, richness of juice in saccharose, and, in some of the northernmost countries, early maturity. As a result of the previous work done in breeding sugar canes, it is now obvious, that a class of canes has been produced that possess, to a large extent, qualities which enable them to resist certain classes of disease. Most of the newer seedlings possess a thicker cuticle than the older varieties and are, therefore, more or less immune from the attacks of insect pests, and possibly some physiological reaction within the plants enables them to withstand the attacks of certain fungoid diseases. More, however, requires to be done in this direction, for the root disease, for instance, is one which does a considerable amount of damage in the West Indies, Hawaii, and elsewhere. In Java, it is held that a larger yield of sugar depends upon the cane possessing an increased vigor, and also greatly upon immunity from disease, and therefore breeding for resistance to disease (the root disease in particular) is one of the first points to be aimed at.

The tonnage of cane per acre is specially a point of great importance. In 1902, Harrison reports that "the results confirm those of previous experiments, that neither the addition of phosphoric acid, of potash, or of lime to the manures favorably affects the sugar contents of the juice of the canes. The effects of nitrogenous manuring appear to be somewhat to retard the maturation of the canes, and thus the juice of canes manured with them is as a rule not so rich in saccharose as is that of canes grown without manure. But this effect is far more than off-set by the larger yields of produce resulting from the application of nitrogenous manures, and to the fact that the increases produced by the nitrogen are principally due to the development of the stalks in length and in bulk, and not to abnormal increases in the amounts of tops and leaves or the production of new shoots to the stool." Watts[7] and Cousins have shown that different manures influence greatly the yield of cane per acre without appreciably altering the saccharine richness of the juice. Moreover, Cousins,[8] Jamaica, holds that "beyond a certain point— 24 per cent. saccharose in the juice— any increase in richness involves a reduction in agricultural yield." He also believes that "the line of development of the sugar cane as a cultivated plant, lies primarily in the direction of increased tonnage of cane, and secondarily, in that of greater purity of juice."

As only a few of the varieties now under experiment possess over 20 per cent. saccharose in the juice, maximum productiveness has not been obtained; but nevertheless, it would appear that disease resistance and a larger tonnage of cane per acre, both of which depend largely upon increased vigor of the cane, should receive first attention.

With the view of obtaining some clue to the more prominent characters of the different varieties in Barbados, several arrows or inflorescences were bagged separately before they were ripe to ensure self-fertilization, and many seedlings have been obtained. As the varieties chosen were hybrids, the records of this second generation should give on analysis results that will be of assistance in the subsequent hybridization work, for the splitting of the different characteristics has been carefully noted.

Many of the previous records of work on the raising of seedling canes show that some varieties possess striking dominant characters, which are transmitted to their offspring. Kobus,[9] in Java, states that "in some cases the fecundating power of the pollen of the Chunnee variety is so strong that more than 95 per cent. of the hybrids resemble the male parent." The hybrids in Barbados, as might be expected, also show that certain external characteristics resemble those of one of the parents.

In the experimental work carried on at Barbados on these lines, only those varieties that have stood the stringent tests on a large scale for a considerable time, under varying conditions of soils and climate, were chosen, as many of the newer seedlings show fluctuating variations when submitted to adverse conditions. Care in securing good parent varieties is of the greatest importance, because the number of varieties which may be kept under trial is limited. After having chosen the variety, it is essential that only the choicest individuals are taken for experimental purposes, for in Java, it has been found that the amount of sugar in a cane varies directly with the weight of the cane, and also, as a rule, heavy plants give rise to heavy offspring.

Once having obtained the desired type of seedling, it will be easy to multiply it to any extent without the necessity of fixing the type by further breeding, as the sugar cane on a large scale is propagated by cuttings and not by seed.

CLASSIFICATION AND AN APPEAL FOR UNIFORMITY.

Having reviewed the method of obtaining seedlings and some of the problems for future work, it becomes necessary to discuss some of the results already obtained. Perhaps the best way is to describe the advances made by the various sugar-producing countries separately. Before doing this, however, it will be advisable to notice in passing the methods of naming and classifying the different varieties of canes.

Most of the older writers classified canes according to the countries of their origin; in many cases their true origin was unknown and, therefore, new names were provided. Subsequently, local names were assigned to the same variety, and shortly a confusing number of synonyms was established. In 1890, Harrison and Jenman[10] recorded that, in their collection of the world's

canes on the Experiment Station in British Guiana, the Bourbon cane (one of the oldest varieties) was represented under six distinct names, and the White Transparent under four.

They therefore suggested that a system of classification should be universally devised, and finally concluded that the best and easiest method was to arrange them in groups according to their outward characters.

Five classes were formed:

(1) Yellowish green or green, often blotched with red.
(2) White, vinous, or brown-tinged canes.
(3) Grey or pink-tinged canes.
(4) Ribbon or striped canes.
(5) Claret or purple canes.

Stubbs[11] in Louisiana, however, recognizes only three classes in distinction to the five of Harrison and Jenman, viz.:

(1) White, yellow, or green canes.
(2) Striped canes.
(3) Solid colors others than in (1).

In comparing these two independent classifications and looking at the synonyms established, it is seen that differences occur, but they show fairly conclusively that the older cultivated varieties of sugar cane were few in number, and presented only those differences which were due to changes of cultivation, climate and environment.

Since the advent of seedling canes it has become customary to designate their origin by the initial letter of the name of country in which they were originally raised, with an affixed number, e.g., B. 147, (Barbados Number 147), D. 95 (Demerara Number 95), T. 24 (Trinidad Number 24), J. 30 (Jamaica Number 30), etc. Seeing, therefore, that the hybridization of the sugar cane is now becoming general all over the tropics, it is essential that some scheme for naming and classification be devised, or else a greater confusion than ever will be the result. All workers, therefore, in the production of seedling canes should see that a letter and a number be affixed to the new seedlings before distribution, and a system of classification based on color and other external appearances be adopted.

If such or any other system were uniformly adopted, it would b eeasy to compare the results of a given variety when grown under different conditions and in different parts of the world.

RESULTS ALREADY OBTAINED.

INDIA.

Efforts to improve the sugar cane in India have only recently been made. With the establishment of the Samalkota Experiment Sugar Station in Madras, the cultivation of the sugar cane under Indian conditions is being carefully studied. Several va-

rieties of canes have been introduced from other countries, and the shipments from Mauritius and Barbados have given good results, the yield of these varieties comparing very favorably with the home canes.

One of the imported Mauritius canes was a ribbon cane called Striped Mauritius, and Barber, in his report on the station for 1904-5, states that this cane has given rise to bud varieties, red and white sports being produced. These sports have been carefully grown and analysed, with the result that the red sports have proved better than any other canes that are grown at the station in respect to richness of juice.

In 1903-4, a number of canes arrowed at the station, and an effort was made to obtain cane seedlings, but without success. In the following year a number of boxes were planted with arrows from different kinds of canes. Two seedlings were obtained from the Mauritius canes, but they lived only for a short time.

Although previous to this time repeated mention of cane seed has been made in different parts of India, no record of the seed being fertile seems to have been reported.

Barber states that these experiments with cane arrows were directed mainly towards the investigation of whether the sugar cane produced fertile seed in India. This has therefore been shown to be the case, but it is thought that the burning dry air of the Indian climate is unsuitable to the successful raising of seedling canes, and that the cultivation of sports appears to be much more practical than the raising of seedling canes. The raising of hybrid canes, however, would possibly be a means of combating many of the diseases that cause so much trouble to cultivators of sugar cane in India.

QUEENSLAND.

The raising of cane seedlings has received some attention in Queensland, as reports to hand state that nine seedlings were obtained from arrows collected in 1889, and five from those collected in 1891. One of these earlier seedlings has given the white sport, referred to previously, which has proved to be the best of all the seedling varieties.

In 1900, a selection of West Indian seedling canes was imported, with the result that last year, at Wellington Point, some gave analyses which compared favorably with the home seedlings, while the information gathered from the latest reports confirms the value of B. 208 (Barbados No. 208) as a cane for cultivation in Queensland.

In 1901, there were obtained by the Queensland Acclimatization Society 700 seedlings, of which 300 were approved plants, and in 1903, 170 plants were selected out of 500.

In 1904, experiments in artificial cross-pollination were undertaken and four hybrids were obtained. These were the results of a cross between B. 208 as seed-bearing parent and Striped Singapore as pollen-bearing parent. This shows that hybridization is possible, and instructive results are expected to follow.

The following will show that seedlings are giving satisfactory results in Queensland: In 1903, only one cane gave over 19 per cent. possible obtainable cane sugar, whereas in 1904 six exceeded this amount. How much this had to do with the season cannot be stated definitely, but it seems to point to the fact that in Queensland, as elsewhere, seedling canes may gradually supplant the older varieties.

Grimley states that B. 208 on one estate gave a "return of 69 tons 6 cwt. of cane per acre with 22.2 per cent. of sucrose, and Brix 23.09, or 21.45 per cent. of possible obtainable cane sugar, or over 14 tons to the acre. These results were obtained under irrigation, and the experiment plot was well manured. The average yield in Queensland per acre for the last seven years was 13.16 tons, so that B. 208 gave more sugar per acre than the average tons of canes per acre in Queensland."[12]

HAWAII.

With the establishment of the Hawaiian Sugar Planters' Association, the propagation of new varieties of canes, which are resistant to disease and at the same time good sugar producers, was considered to be of paramount importance.

In the season 1904-5 no young canes were obtained from the home-grown seed, but large numbers of seedlings were obtained from seed introduced from Barbados, Jamaica and Trinidad. In all, 279 seedling canes were obtained and planted out; ninety-three of these were cut up and replanted as cuttings, while the remainder were allowed to remain to flower, when it was hoped that a considerable quantity of fertile seed would be obtained.

Artificial cross-pollination experiments were conducted last season, but, so far, the results are not known to the authors of this paper.

The introduction of foreign varieties is largely practised, seedlings from Demerara, Barbados and Queensland have been introduced, and it is stated that "D. 117 holds the lead among the recently-introduced varieties and is a promising cane worthy of trial under the diversified conditions of the island." Among other very promising seedling canes are B. 147, B. 156, B. 208, D. 145, and Q. 1.

LOUISIANA.

Owing to the shortness of the growing season, which is limited to about eight months on account of frosts, the home canes in Louisiana rarely arrow. Seedlings from these home canes have not been obtained, and therefore planters have to rely upon imported varieties. Seedling canes from Demerara, Barbados, Jamaica and Queensland have been imported, and submitted to trial at the Experiment Station. A large number were found to be unworthy of recommendation to the planters, others are still under experiment, and two of the Demerara seedlings, viz., D. 74 and D. 95, have surpassed all the home canes.

D. 74 is a tall, green, erect cane with long internodes, long and deep roots, ratoons (i. e., sprouts for second crop) well, and has a large sugar content. The individual canes are large and heavy.

D. 95 is a large, purple, erect cane with long internodes, long and deep roots, ratoons well, has a large sugar content, and large individual stalks.

Blouin reports that both these canes are very hardy, mature early, and that their erect habit renders them better able to withstand storms and makes them more easy to harvest.

During 1905, D. 74 arrowed in Louisiana, this being the first seedling that has flowered in that State.* From this it may be inferred that this cane is one which quickly matures. If it matures while the older varieties remain immature, and gives a high sugar content, it should prove to be a valuable cane to sugar planters in Louisiana. The planters fully appreciate the value of these varieties, as it is estimated that nearly four-fifths of them have introduced one or both of the Demerara seedlings into their cultivation, and, if these canes continue to flourish, nearly two-thirds of Louisiana's cane area will be planted with them in two or three years' time.

MAURITIUS.

A large number of varieties of canes are grown in Mauritius, amongst which are two sports of the Striped Tanna, which have been submitted to extensive trial. The White Tanna is whitish and resembles the parent cane in many respects and is now held in favor. The Black Tanna, also a bud variety of the striped cane, presents many characters of the parent cane, but is not extensively grown.

Seedlings were successfully raised shortly after the discovery

*Since this paper was written, it has been announced that seedling canes have been successfully raised for the first time in Louisiana (Agricultural News Barbados, Vol. V, p. 307).

of fertile seed in Java and Barbados, a large number of which were distributed to estates. These seedlings gave such good results that managers frequently started seedling nurseries of their own, and much confusion in nomenclature followed.

The first seedlings grown were chosen haphazard, but eventually various systems were evolved, such as planting in alternate rows and bagging the arrows on the chance of getting fertile seeds.

It is also interesting to note that, as early as 1889, a method of what may be called natural hybridization, by which several hybrids have been obtained in the West Indies, was fully discussed by Boname,[13] but was thought to be impracticable on a field scale. It was suggested that the inflorescence be enclosed in muslin bags when quite young and then the inflorescence of another be introduced when its flowers were ready for pollination. No record can be found of this method being practiced in Mauritius.

The raising of seedlings in Mauritius appears to have centred around the collection of the arrows from their best varieties. The Big Tanna, which is one of their most vigorous canes, has received considerable attention, and a large number of seedlings have been obtained from it. Although many of these seedlings have proved to be worthless and others have shown great fluctuations, yet a considerable number have been produced, some of which not only show a greater saccharine content than the other varieties, but also a greater resistance to disease, and, consequently, give a larger yield of sugar per acre than most of the older varieties.

JAVA.

The raising and cultivation of seedling canes have been taken up to a considerable extent in Java, on account of their comparative freedom from disease. After the discovery of fertile seed of the sugar cane in 1887, many of the larger planters cut the cane arrows, planted them, and raised large numbers of seedling plants. From these they selected such as had a high saccharine content and showed themselves able to resist disease for planting on a large scale, and then finally selected those which were best suited to their estates.

Owing, however, to the insufficiency of the trials before introduction into the general cultivation, much distress was incurred, and therefore planters began to look to the Experiment Stations for selected seedling canes.

In 1894, Wakker, the Director of the East Java Experiment Station, discovered that the Cheribon cane bore infertile pollen, while the ovary was normal. Bouricius crossed the Cheribon with the Fidji, and later Kobus crossed it with the Chunnee, one

of the imported East Indian canes, for this showed a large proportion of fertile polien. The two chosen varieties were planted alternately in rows in order to obtain natural cross-pollination. A very large number of seedlings was obtained by sowing seeds from the "self-sterile" arrows of the Cheribon, many of which combine the high sugar content of the Cheribon with the disease-resisting power of other selected varieties.*

All the resulting seedlings are tested in the station for four years before being recommended for general cultivation. In this way a race of hardier canes has been established, and the sugar content has not been noticeably decreased, although one of the varieties used as a parent was rather low in percentage of saccharose.

The choice of the Chunnee variety as one of the standards to be used for crossing purposes has even been more valuable than the experimentalists dared at one time to hope, for all the seedlings at the Experiment Stations that are the descendants of the Chunnee are less subject to root disease, as well as to other maladies. They are, however, somewhat hard, which is an inconvenience for crushing purposes, but it is not thought that this property is undesirable, as it is counterbalanced by others that are useful.

Efforts are now being made to raise other races of plants, one —a more hardy race of seedlings—by crossing those seedlings already obtained with the immune variety Chunnee, and the other —a richer race of seedlings—by crossing seedling canes with the Cheribon, and also with other seedlings.

Although the results are not coming out exactly as anticipated, an examination of the following table will show that considerable improvement has been made.

The contents of the following table have been extracted from that given by Kobus[14] in 1905, embodying the experimental tests with the different varieties of seedling canes at the East Java Experiment Station. The figures given by Kobus have all been converted into English units so that they may be used for comparison with the results obtained in the West Indies. This table illustrates clearly how the yield of many seedling canes is much better than that of the standard variety—Cheribon:

*In 1905, over 16,000 seedlings were raised at the East Java Experiment Station. Of these, the parentage of 7,170 was known on both sides, for they were produced by the above method, and that of 7,400 others was known on one side only.

TABLE III.

No.	Soil.	Tons of cane per acre.	Per cent. pure sugar in cane.	Pounds of sugar per acre.
Cheribon	Light	37.9	11.79	9,928
146	"	62.8	13.55	19,085
213	"	62.9	13.34	19,250
247 B.	"	70.1	11.54	20,394

By this is can be seen that many of the seedling varieties give an estimated yield of sugar per acre of about double that given by the old standard variety.

So far, no records have come to hand from Java to show that hand cross-pollination has been successful, but now that it has been shown to be possible in several different countries, there can be no reason why the raising of hybrid sugar canes under control should not be as possible in Java as elsewhere.

CUBA.

Experiments have been conducted with the introduction of standard varieties and seedlings from Java, Queensland and the British West Indies. After considerable testing, many of these are being introduced into the general cultivation. B. 208 has been giving excellent results both in percentage of saccharose and purity of juice.

Four years of careful hybridization resulted in but two seedlings, but during the last year (1905-6), owing to a favorable season, over 600 seedlings have been obtained by Atkins[15] at the Harvard Experiment Station, and nearly all of these are the result of hand cross-pollination. Emasculation was effected during early morning when the anthers were full-grown but unexpanded, and pollination was continued for several days, the spikelets being kept under gauze cloth. It is moreover shown in his report that great care must be taken with the germination of the seeds, much depending upon the soil used, on the depth to which they are set, and on the watering.

This report is, without doubt, a valuable one, as it shows conclusively that, with a favorable season, seedlings of the sugar cane can be obtained in large quantities as the result of cross-pollination.

BRITISH WEST INDIES AND BRITISH GUIANA.

Since the establishment of the fact in 1887 and 1888, by Soltwedel in Java and Harrison and Bovell in Barbados, that the sugar cane at times does bear fertile seeds, systematic at-

tempts have been continued in the West Indies and British Guiana towards the raising of improved races of seedling canes. All the different methods of selection before referred to have been adopted, with the result that thousands of seedlings have been raised, from which a few good ones have been chosen and recommended to planters for trial. It was thought, however, that it was essential to select both parents, and the various methods to ensure the crossing of the chosen varieties were given an extended trial. The method of planting in alternate rows varieties that had practically unisexual flowers, which has given such good results in Java, has been experimented with, but, owing to the success of Lewton-Brain in 1904 at Barbados in obtaining seedlings by hand cross-pollination, it is now held that artificial hybridization of the sugar cane is practicable and ensures the best results in the shortest possible time.

Having briefly referred to the methods adopted for the raising of seedling canes in the West Indies, some of the results already obtained may be reviewed in order to show what improvement has been made. The "Bourbon" cane was at one time the standard cane of the West Indies, but owing to fungoid diseases its cultivation had to be given up and other varieties substituted in its place. In Barbados the cultivation of the Bourbon cane has been entirely abandoned, and another variety, the White Transparent, has taken its place as the standard cane.

Barbados.—Thousands of seedlings are raised yearly in Barbados from the planting of the arrows from the better varieties, and these are submitted to rigorous selection on the tonnage of canes per acre and the chemical analysis of the juice. During the last five years in Barbados over 20,000 seedling canes have been raised and planted out, but less than 1 per cent. of these have stood the stringent tests of field and chemical selection applied to them. In the season 1904-5, over 7,000 plants were raised from seed, and out of these only ninety-five were considered worthy of further propagation. It may be urged that a large number of seedlings are in this way wasted every year, but it is held by Bovell that, owing to the limited extent of the experimental grounds, it is necessary to limit the cultivation to seedlings that give an estimated yield of 30 tons of canes per acre and a saccharine content of over 18 per cent. This year, 1906, about 5,000 seedlings have been planted out, from which it is not expected to choose more than 100 for further propagation, and it is doubtful whether more than one of these will prove worthy of recommendation for planting on a large scale.

Work on these lines has been continuously pursued in Barbados since about 1888, and the following tables of results, extracted from the reports recently issued by d'Albuquerque and Bovell on the experiment work with sugar cane, under the direction of the Imperial Department of Agriculture, show

that many of these seedling canes give results vastly superior to the standard variety:

TABLE IV.

MEAN RESULTS—BLACK SOILS—FOR SEASONS 1900-5.

Cane.	Canes—Tons per acre.	Per cent. of rotten canes.	Saccharose pounds per gallon.	Quotient of purity per cent.	Saccharose. Pounds per acre.	Muscovado yield—tons.
B. 1,529 (1904-5).....	28.92	1.54	2.406	92.18	8,477	3.03
B. 147 (1900-5).....	28.35	3.77	1.912	86.88	7,006	2.50
B. 208 (1900-5).....	24.72	4.93	2.250	90.70	6,863	2.45
White Transparent (1901-5)	25.22	5.99	2.038	89.70	6,453	2.30

TABLE V.

MEAN RESULTS—RED SOILS—FOR SEASONS 1900-5.

Cane.	Canes—Tons per acre.	Per cent. of rotten canes.	Saccharose pounds per gallon.	Quotient of purity per cent.	Saccharose. Pounds per acre.	Muscovado yield—tons.
B. 1,529 (1904-5).....	27.12	1.67	2.270	93.79	7,428	2.65
B. 208 (1900-5).....	26.78	5.52	2.146	91.23	6,695	2.39
White Transparent (1901-5)	22.24	4.93	1.979	90.09	5,404	1.93

It will be seen by the above tables that B. 1,529 gave an average, in both red and black soils, of 2,024 pounds of sugar per acre more than White Transparent, while B. 208, a cane which has lately become extensively cultivated in different parts of the West Indies and elsewhere, gave a yield of 410 pounds in black soils and 1,291 pounds of sugar per acre in red soils, more than the standard variety.

These tables have been prepared as they give the results of experiments over an extended number of years, but if the table, published in the report,* which embodies the results of different plots of new varieties for 1903-5, be examined, it will be found that White Transparent comes out eightieth on the

*A brief summary of this report, together with the table referred to, will be found in the West Indian Bulletin, Vol. VI, pp. 341-60.

list of those cultivated in black soils, while the Bourbon is still lower.

It has often been urged that these results are based upon small plots, which do not furnish a sufficient quantity of cane for the tests to be of value to sugar planters, but tables are also given in the above-mentioned report which show that seedlings B. 147 and B. 208 are giving better results than White Transparent when grown on an estate scale. These tables have been furnished through the courtesy of Mr. A. Cameron, and embody the results obtained on certain estates in Barbados under his direction, on which canes of different varieties have been grown, and show comparisons between 693½ acres of B. 147, 33 acres of B. 208, and 411 acres of White Transparent for the seasons 1903-5.

Jamaica.—Cousins, in his report on the work of the sugar experiment station in Jamaica for 1905, states that some very good seedling canes, resulting from naturally cross-fertilized seed, have been produced and are being submitted to a rigid selection.

About 3,000 seedlings are now being grown each year in Jamaica; therefore a series of Jamaica seedlings worthy of trial on an estate scale should soon be available.

In the trials of the imported varieties, B. 208 gave a tonnage of 65.5 tons of canes per acre and is being recommended to planters "as the most promising seedling cane at present grown in Jamaica."

The author of the report also points out that about 100,000 plants of selected varieties were distributed during the past year, which clearly shows that the planters of Jamaica fully appreciate the introduction and trial of new varieties of canes.

Leeward Islands.—The results recently issued by the Imperial Department of Agriculture for the West Indies on the work carried on by Watts at Antigua show that B. 208 gave an average yield of 9.347 pounds saccharose per acre in plant canes and 5,001 pounds in ratoons, against 7,014 pounds in plant canes and 4,265 pounds saccharose per acre in ratoons of White Transparent. In St. Kitt's, B. 208 gave an average yield per acre of 8,675 pounds saccharose in plant canes and 6,648 pounds in ratoons against 7,014 pounds saccharose in plant canes and 5,861 pounds in ratoons of White Transparet, while B. 147 gave a yield of 7,133 pounds in plant canes and 6,174 pounds in ratoons.

As these figures are the mean results of a large number of plots carried on for four years in plant canes and for three years in ratoons in Antigua and for five and four years, respectively, in St. Kitt's, they show that seedling canes are of considerable economic value to planters in the Leeward Islands.

British Guiana.—In British Guiana, up to the beginning of 1905, nearly one-third of a million of seedling canes had been raised by obtaining seed from good standard varieties, and 26,000 of these had been selected for field experiments. Harrison, at the last West Indian Agricultural Conference (1905), stated that 14,800 acres were under cultivation with varieties other than Bourbon and of these about 13,000 acres were occupied by new seedling varieties, the favorite ones with the planters being D. 109, B. 147, D. 145, D. 625, and B. 208. It is estimated that D. 145 bears a ratio to the Bourbon in respect to saccharose yield per acre as 170.8 is to 100.

At the end of 1905 the area under cultivation in varieties of canes other than Bourbon extended to 18,000 acres, and as opportunity offers, further extension is being undertaken. This is nearly one-fifth of the acreage under cane cultivation in British Guiana, and shows that planters have been ready to appreciate what has been done for them in the matter of new varieties of canes. The average returns on an estate of over 5,500 acres show that seedling canes, tested over a period of five years on an area of over 2,000 acres, gave nearly 26 per cent. more sugar than the Bourbon cane under similar conditions.

In an official report presented in May, 1906, by Harrison on the Sugar-cane Experiments carried on under his direction at British Guiana, he states: "Some measure of the success of the administration of the Imperial grant-in-aid for the West Indies may be found in the extension of the area occupied by new seedling varieties in the colony from about 550 acres in 1899, to 20,065 in 1906, and in that during the last five years we have recorded that new varieties of seedling canes have given, over large areas, mean results of 8, 10, 22, and 35 per cent. higher than the average of the returns obtained from the Bourbon during the same period."

Two Demerara seedlings have also shown their superiority in many respects to the home canes in Louisiana.

Trinidad.—In Trinidad, experiments on a small scale have been carried on with seedling canes, and reports show that D. 95 has given an average return of 23.65 tons of cane per acre, as against an average of 21.33 tons per acre for White Transparent and 16.43 tons per acre for the Bourbon.

By closely examining these results obtained throughout the different portions of the West Indies, it will be realized that seedling canes are likely to prove an important economic factor in the improvement of the sugar industry. Much has already been accomplished, but it is expected that in the future canes of still higher value will be raised.

HYBRIDS IN BARBADOS.

The experimental work begun by Lewton-Brain in 1904 in artificial cross-pollination and self-fertilization proved successful, and therefore in 1905 systematic attempts to raise new hybrids were commenced.

Crossing was performed in two directions, the pollen parent in one cross being used as the seed parent in the other cross; in other words, one variety was utilized as the female parent in one cross and as the male parent in the other.

"The arrow which was to become the seed parent was carefully selected on a cane free from disease, bagged before it began to emerge from the leaf-sheath, and allowed to remain until a length of at least six inches presented itself in the air and to the rays of the sun. It was found that very young spikelets were affected seriously by the sun after they had been operated upon, but that, if they remained exposed until the glumes were beginning to turn slightly red, they stood the severe handling much better. Careful microscopic examination of the flowers at this stage revealed very little mature pollen in the anthers, and the stigmata were not in a receptive condition, being still in the white, immature state. There could, therefore, be no danger of self-fertilization. It was also found that if the spikelets happened to present a lateral view, the glumes could easily be separated, and the anthers removed without rupture."

Only those canes which had stood the strongest tests on a large scale for a number of years were used in the experiments. Over 600 spikelets were emasculated and artificially pollinated, of which over 400 were spikelets of B. 147 and B. 208.[16]

The results of this work have not been satisfactory, as an unfavorable season with windy, showery weather destroyed all chances of good success.

Some further particulars of the results obtained by Lewton-Brain in 1904 in Barbados may be interesting. He experimented with some of the best Barbados varieties as the parent plants and as a result obtained five hybrids of known pedigree. These have been carefully grown, and although it is impossible at present to say what their commercial value will be, yet it may be interesting to record a few external features that have been noticed during the growing season.

The pedigree seedlings that have been obtained consist of the following*:

*In the description of the crosses that gave hybrids the seed-bearing parent is always given first and the pollen-bearing parent second, thus:—cross between B. 1,376 × B. 1,529 implies a cross between B. 1,376 as seed-bearing parent or female parent and B. 1,529 as pollen-bearing or male parent.

(1) Three holes of B. H. 1; cross between B. 1,376xB. 1,529.
(2) One hole of B. H. 15; cross between B. 3,289xB. 1,529.
(3) One hole of B. H. 18; cross between B. 3,289xB. 1,355.

DESCRIPTION OF PARENTS.

In the following description of the varieties used in hybridizing only the more important characteristics are noted and are chiefly those which can be used in comparing with the descriptions of the hybrids:

B. 1,376.—Germinating power, good; color, dull yellowish-green; habit of growth, more or less recumbent; internodes, cylindrical; eyes round; dried leaf-sheaths fall readily; disease resistance fair.

B. 1,529.—Germinating power, under average; color, red; habit of growth, upright; internodes variable but generally roundish; eyes round; dried leaf-sheaths somewhat adherent; disease resistance good.

B. 3,289.—Germinating power, fair; color, yellowish-green; habit of growth, recumbent; internodes cylindical; eyes round; dried leaf-sheaths fall readily; disease resistance very good.

B. 1,355.—Germinating power fair; color, red; habit of growth, generally upright; internodes variable, but generally roundish; eyes round; dried leaf-sheaths fall readily; disease resistance fair.

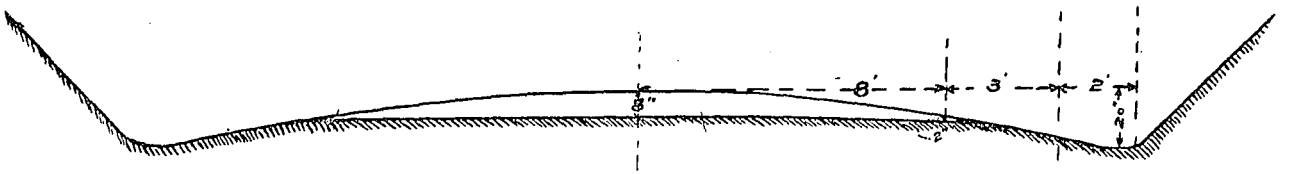
DESCRIPTION OF HYBRIDS.

Cross 1.—B. 1,376 x B. 1,529.—Owing to some differences in the three holes of the cross B. 1,376 x B. 1,529 it has been proposed to cultivate them separately under different nomenclature. The following are the characters:

B. HH. 1 = B. HH. 3:—Color, yellowish-green; habit of growth, recumbent; internodes roundish: eyes round; dried leaf-sheaths somewhat adherent; disease resistance fair.

B. HH. 2:—Color, yellowish-green; habit of growth, upright; internodes variable; eyes round; dried leaf-sheaths fall readily; disease resistance fair.

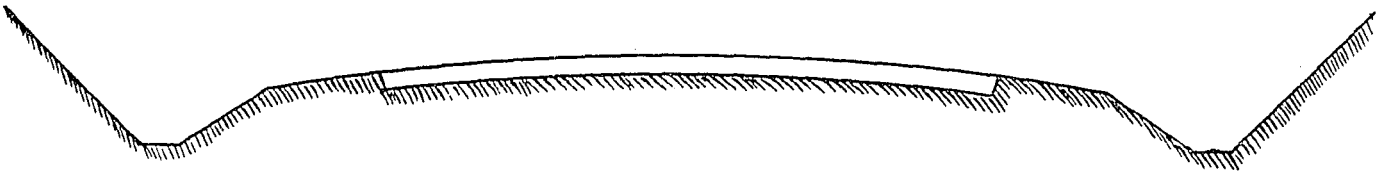
All the canes from this cross were yellowish-green in color, thus resembling the seed-bearing parent B. 1,376, and not B. 1,529, which is a red cane. The canes of two holes of this cross were recumbent in habit of growth, taking somewhat after B. 1,376, while the canes of the other hole were upright—a characteristic of B. 1,529. The canes were all above average size, therefore resembling B. 1,376 rather than B. 1,529, which is a thinnish cane; but they possessed internodes which resembled closely those of B. 1,529. Two-thirds of the canes also resembled B. 1,529 in that they had leaf-sheaths which were somewhat adherent to the stem.



Recomended form of Macadam Road.

Advantages:—

Subgrade can be shaped with road scrapers.
Greatest thickness of metal where subject to greatest wear
Water percolating under macadam quickly drains away—
Gutters can be cleaned by scrapers.—
Additional width which can be brought under roller.



Macadam Road with deep ditches and retaining shoulder

Disadvantages:—

Work must be done with pick and shovel
Double rolling of subgrade
Subgrade becomes saturated in protracted wet weather
Ditches must be cleaned by pick and shovel.
Dangerous nature of ditch to careless drivers.—

A construction frequently seen in Hawaii which gives much trouble in maintenance.—

G. H. G.

Cross 2.—B. 3,289 x B. 1,529=B.H. 15.—Color, yellowish-green; habit of growth, upright; internodes roundish; eyes round; dried leaf-sheaths somewhat adherent.

The canes of this cross died early through the effects of the excessive drought that has been lately experienced and therefore the characteristics could not be closely followed.

Cross 3.—B. 3,289 x 1,355=B.H. 18.—Color, yellowish green; habit of growth, slightly recumbent; internodes variable, but generally roundish; eyes round; dried leaf-sheaths adherent; disease resistance fair.

The canes of this cross were drought resistant and resembled in color and habit of growth B. 3,289, in the shape of internodes B. 1,355, but differed from both parents in possessing adherent leaf-sheaths.

Owing to the unfavorable season, during this last year, it was thought advisable to cut up all the canes available from these crosses and not to submit any of them to chemical analysis and, therefore, it is impossible, at present, to say what will be the commercial value of these canes. During this next year the characters of the hybrids will again be closely followed and recorded in order to see if any of them are variable.

SELF-FERTILIZED SEEDLINGS.

In 1904, several arrows of the better varieties were also bagged to obtain self-fertilized seedlings in order to investigate, if possible, some of the dominant characteristics of our different varieties of sugar-cane. B. 1,529 gave forty-two seedlings, which showed the following variations*:

Weight of canes per hole—extremes 5 lb. to 47 lb.

Saccharose per gallon—extremes 1.256 lb. to 2.398 lb.

Glucose per gallon—extremes .028 lb. to .139 lb.

It also showed that its red color was a recessive character, a fact which is borne out by the seedlings obtained by the cross between it and B. 1,376. It might also be thought that its upright habit is also recessive, for the self-fertilized seedlings presented habits, recumbent to upright, in the ratio of 3 to 1. One of its dominant features is the inherent richness of its juice—a fact already noticed—when compared with the analysis of the juices of other seedlings grown under similar conditions.

B. 1,376 gave twenty-seven seedlings that also varied considerably as may be seen by the following table:

Weight of canes per hole—extremes 8 lb. to 50 lb.

Saccharose per gallon—extremes 1.196 lb. to 2.015 lb.

*These figures were obtained from Prof. J. P. d'Albuquerque, Chemist-in-charge of Sugar-cane Experiments, and Mr. J. R. Bovell, Agricultural Superintendent, Barbados.

Glucose per gallon—extremes .039 lb. to .156 lb.

It is impossible at present even to speculate upon its various characteristics, as the seedlings were so varied, but most of them were yellowish-green in color and somewhat recumbent in habit of growth.

In all, sixty- nine self-fertilized seedlings have been investigated and, therefore, it may be held that the results above given have been deduced from a very small number, but they clearly show that much can be learnt about the inheritance in the sugar-cane by inquiring into the dominant and recessive characteristics of the different varieties, and then it may be possible to build up an ideal cane.

OTHER COUNTRIES.

Although, in other countries, seedling canes have not been raised systematically, yet records show that introduced seedlings are giving satisfactory results in all places where they are cultivated.

In Pernambuco, Brazil, seedlings were first attempted to be raised in 1890,[17] and in 1899 it was reported that a seedling cane was giving excellent returns. It was, at first, immune from the "gumming" disease, but after cultivation for some time it became more or less liable to the attacks of this disease. Since then other seedlings have been produced, which possess a greater immunity from disease.

In Natal, West Indian seedlings, B. 109 and D. 95, sent from Antigua, have made satisfactory growth and are being cultivated on increasing areas throughout that colony.[18]

In Fiji, it is stated by Knowles in his reports during 1905, 35 acres of different varieties of canes are being grown for trial and for hybridization experiments. This is possibly the first time that such experiments have been conducted in Fiji, and good results are being looked for.[19]

In Martinique, many of the West Indian seedlings as well as many home seedlings are giving larger yields of sugar per acre than the standard varieties.[20]

In Reunion, there are large numbers of different varieties of canes under cultivation, but no mention of systematic attempts at raising seedlings can be found.[21]

GENERAL CONCLUSIONS.

In conclusion, it must be held, after careful examination of the various results, that the production of new varieties of canes by selection and hybridization has proved a valuable means of improving the quality of the sugar-cane. The experiments carried on in the West Indies are most encouraging, for it has been shown that not only are the seedlings more

resistant to certain classes of diseases through their increased vigor and growth, but that they also give a larger yield of sugar per acre; and the results from Java, Hawaii, Queensland, Louisiana, and elsewhere all confirm those obtained in these islands.

The success of the results already obtained should stimulate workers in this subject to greater efforts in the production of new races of canes, for it is not only necessary to improve the productiveness of the plant, but it is essential that races of greater disease resistance be raised, for whereas many of the seedlings at present are immune from one disease, they are more or less susceptible to another, and also that a large number of varieties be at the disposal of cane planters, owing to the great differences in climate and soils of cane-producing areas.

That climate and soil are the paramount influences exerted in the sugar-producing capacity of different varieties has clearly been shown by the difference in yields and other characteristics manifested by the same cane in different localities.

Therefore, following the example of European beet growers who think that the practice of persistently growing their crops under the same conditions of soil and climate is a mistake, the seedling canes are distributed in experimental plots on widely different areas and under different conditions. The seedlings are also grown in competition for a number of seasons before any definite conclusions are drawn as to their relative value, owing to the varying time of their maturity and the rapid deterioration of over-ripe canes, and the varying germinative power of the seed cuttings.

Whereas considerable improvement has been made by selection and natural hybridization, it is expected that hybridization under control should give desired results more rapidly, for by the careful choice of parents it is hoped to combine some of the good qualities of both parents in the offspring.

The chief difficulty against obtaining large numbers of hybrids has been due to the small size of the flowers and the general habit of growth, but by careful manipulation, as described in the West Indian Bulletin, Vol. V, pp. 362-3, and Vol. VI, pp. 394-402, these difficulties can be surmounted, and good results should follow in seasons favorable to hybridization experiments.

The increasing fertility of the newer seedlings—as shown by the fact that recently nearly 1,000 seeds from a single inflorescence have been known to germinate, whereas a few years ago thirty to fifty was the greatest number recorded—makes it probable that many of the difficulties that have previously kept this work in check will sooner or later be overcome.

Probably the greatest improvement in the future will result from first analysing the different characteristics of the varieties to be used as parent canes by raising large numbers of self-fertilized seedlings and then building up an ideal cane, which will stand the rigorous tests of field selections, and analysis in the laboratory. In the carrying out of this work, great variations will be noticed owing to the hybrid origin of the varieties to be used for crossing purposes; but, then, by raising large numbers of self-fertilized seedlings, the heredity value of the parent varieties may be learnt from careful analyses of the offspring. In other words, an examination of varieties of canes for the so-called "centgener power" of Hays may be of practical importance.

In short, "the great expectations once held of seedling canes may not have been realized," yet "the greatest hope for the future lies in the expectation that it may become increasingly practicable to raise canes of definitely known parentage from carefully selected plants possessing to the greatest degree the characteristics of disease resistance, high sucrose yield, heavy tonnage of cane, and the other properties which have been previously mentioned as marking a sugar-cane of high economic value."[22]

ROAD CONSTRUCTION IN THE TERRITORY OF HAWAII.

By Guy Gere, C. E., *County Engineer, Oahu County, Hawaii.*

(Read before the Hawaiian Engineering Association.)

That Hawaii is not a laggard in the construction of good roads is very evident to any one at all conversant with what has been done since 1893, or to one who hears the opinion of those of our visitors who are interested in the subject.

The people fully appreciate the convenience of a hard road with a good surface, even though its value as an investment is not always appraised at its true value.

Hawaii has undertaken successfully some of the boldest projects of wagon road construction to be met with anywhere in America. The Nuuanu Pali road on Oahu, the main road through Hilo and Hamakua on Hawaii, and some of the roads on Maui being notable examples.

One may say that road construction as such really began in 1893, as previous to that time many districts were not connected with their neighbors and many more had no roads other than horse trails, which will live for many years in tradition on ac-

count of their perilous nature and of the many mishaps which occurred on them.

Such wagon roads as were in existence, generally had their location determined by the trails, and as a result there was much climbing up and down hills with great waste of time and muscle. Even now many of our main roads have grades which are excessive and most of which could be eliminated by proper grading or relocation. The State Engineer of New York in his report stated that "one of the greatest defects and often one of the most expensive to remedy, is a faulty location for a road."

The load that can be hauled over the good portion of a road is limited by the load that can be moved over the steepest grade in that road. The higher the grade the smaller will be the load that can be moved by the same amount of power, no matter what the condition of the roadbed may be.

I do not intend to go into the matter of cost of moving loads over improved and unimproved road beds except to say that it has been well established by the Good Roads Department of the United States Department of Agriculture, that the average cost per ton mile over macadam roads is about 45% of the cost of the same load over dirt roads.

Under the conditions which have existed here of limited appropriation to perform certain work, cut generally below the cost estimate of the engineers by careless and ignorant legislation, the demand that a greater length of narrow and poorly constructed road, instead of a shorter section well built, has frequently prevailed.

Except in very exceptional cases it is better to build less and build right, and thus keep down the repair account, for as this is an annual charge, you can readily appreciate the advantage of keeping it as small as possible.

Hawaii has weather conditions to contend with which are excessively severe and which are probably not equalled anywhere on the mainland in the United States. Long comparatively dry spells with a steady wind blowing, which in some districts is almost a gale, are broken by the torrential rains, which are not the exception but the rule, and which put the poorly constructed roads of easy grade in an impassible condition on account of the mud and the heavy grades in a like condition from washouts.

The cost of keeping many of these old roads open for travel in the past ten years has been far in excess of the first cost of a good macadam road and the interest on the same and the cost of maintenance.

In all of the districts with which I am familiar, comprising the Island of Hawaii and Oahu, we have to our hand a road material unsurpassed for wearing purposes; low cost of quarrying and transporting this to its final destination in the roadway, place us on an equality with the most favored. True, our rock varies in

quality from the hard, close-grained trap to the mud rock and corals, but the materials for building a first class road can always be had. It only remains for their intelligent use.

The question of what shall constitute the road bed should always be governed by the selection of the best material available.

In the earlier built macadam road it was considered an unnecessary refinement to screen the rock and frequently not considered even necessary to roll it other than with the traffic.

These roads naturally show defects that have been remedied in most of those built later.

All stone used in macadam should be graded to even sizes and placed in the road with the larger size below.

Another common fault in road construction is a poorly constructed subgrade. A good surface, properly shaped and rolled, is a necessity for a well wearing road.

Again the roadway is made too narrow. The wider the road and the better the shoulders the less will be the repairs. Under ordinary conditions the macadam should be not over 16 and not less than 14 feet wide and have not less than a three-foot berm on each side. The practice of holding the macadam in place by means of a stone curb I think a mistake. Where the curb forms the gutter line, as is frequently the case, the wheels are continually loosening the curb stones and crowding them into the gutter, releasing the macadam on the edge and causing it to ravel. Where the curb is set in the ground with a berm outside, the macadam and berm wear away, leaving the curb projecting and frequently forming a gutter on the inside of the curb line.

Neither do I approve of earth shoulder against the outside of the macadam. They add greatly to the cost of preparing the subgrade as they must be excavated after the road is shaped and rolled and the subgrade then rerolled, and they tend to prevent any water which may accumulate under the macadam from quickly draining off and thus soften the foundation. It is better that the entire width of roadway be of crushed rock rolled out so that the continued line of the road surface is the top of the berm. It may be objected that the wheels will cut through the thin crust at the edge, but two or three inches of macadam will carry a heavy load if the subgrade is not water soaked and heavy loads will come upon the edge only when two loaded teams pass each other.

Another advantage of doing away with the shoulder is that the subgrade can be surfaced by road scrapers and rolled its full width.

Wide shallow ditches, the inside slope being a continuation of the parabolic curve of the crown, are preferable to deep narrow ditches, for here again the question of cost of construction is simplified by permitting the use of scrapers and road machines, while it also permits the rolling of the entire subgrade. In short,

the economy of the use of machines for grading has been almost ignored in our road construction, the sentiment seeming to be that it is better economy to add to the cost of the works by giving more days pay to the worthy voter.

The most glaring defect of our road construction has been the poor drainage provided. It is not hard to understand either when consideration is taken of the clamor and demand that the road must get there some way. Drainage costs money and whatever is saved in the drainage builds so many feet additional road. Those that come after have to pay the price, however, generally several fold. All cross drains should be of stone or concrete, and in my opinion never less than 18″ square, so that they can be cleaned speedily and frequent enough so that there will be no trouble in caring for the water.

All bridges and culverts under 40 foot span should be concrete.

The grade of a road is an important factor in its wearing quality and ability to withstand weather. Where practicable I believe 5 feet in 100 should be the maximum gradient on our belt roads. Macadam will not stand on steeper grades than that under the severe conditions imposed here.

On grades of 3% and over the gutters should be paved with stone.

The great problem is how to maintain the roads we already have and at the same time meet the constant demand for extension with the limited means at hand.

The automobile brings a new problem in maintenance. The rapid passage of an automobile loosens and throws out the binder material, creating dust and causing raveling of the macadam.

Much capital is invested in the making of cars, much also is represented by the cars themselves, and much money is spent by the tourist through the country.

There is a feeling of animosity held by many against any who run an auto over the roads largely due to a few reckless drivers who always hog everything in sight with a reckless disregard for the rights of others. This popular prejudice against the automobile caused a measure to be urged on the present New York General Assembly by which automobiles would be taxed $2.50 for each seat, the proceeds to go to the repair of the highway. Automobilists are good road enthusiasts and do pay considerable money into the treasury which should rightly belong to the improvement and maintenance of the roads.

Crude oil, coal tar, salt water and several patented applications of a soapy nature have been tried in many places on the mainland. Crude oil seems to be the only available solution for us here as coal tar is barred on account of its distance from the source of production. Many experiments in its application have been made by the Honolulu road department and the showing made on some of the streets in the Makiki district this past sea-

son seems promising. Details of the methods used and their cost, and the results obtained could well be made a subject for discussion before you at a later date.

One great handicap in road construction is that, except by private experiment, no one knows what it has cost to construct and maintain any one particular mile or section of road. In all these years of construction no intelligent business method or plan has been adopted or carried out for the intelligent study of what is best, and we have been guessing at conclusions and learn little by experience.

If the kind, method and cost of construction of each section were carefully kept and tabulated, and thereafter every dollar spent in maintenance of that particular section charged against it, data would be obtained which would furnish a valuable basis for future work.

Business methods in road construction are as essential for a proper expenditure of the people's money as any other factor.

The needs of Hawaii are many. The development of the "Belt Road" on each island is a burning question and it seems to me that a Territorial aid bill might well have been passed by our legislature. Horatio S. Earle, State Highway Commissioner of Michigan, is a strong advocate of "National Reward for Roads." The gist of the law he favors is contained in Section 7 of the Michigan State Reward Law:

"Every mile of well graded road on which the steepest incline shall not exceed 6 per cent. and the width shall not be less than 18 feet between side ditches, and which shall be properly drained, and crowned so to shed water quickly to the side ditches, and which shall have a wagon way or travel track not less than 12 feet wide, made in two courses and thoroughly compacted, if built in accordance with the plan and specifications of the United States Highway Commissioner and approved by him, shall merit reward as follows: If built of gravel, $500.00 per mile; if built with one course of approved stone and one course of gravel, $750.00 per mile; if macadamized, $1000.00 per mile.

"If the United States Highway Commissioner shall by investigation or experiment find that some other material than those mentioned in this section is equal to them or any one of them, then he may prepare plans and specifications for roads to be built of such material, and shall place them in one of the classes described in this section, and such roads shall be entitled to receive the reward of the class to which they are assigned by the said Commissioner."

If our Delegate can assist this measure through Congress and get Hawaii in the first flight it would well be worth while.