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THE HAWAIIAN PLANTERS' MONTHLY

PUBLISHED FOR THE

HAWAIIAN SUGAR PLANTERS' ASSOCIATION.

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WEATHER AND CROP.

March was an unfavorable month for the growth of sugar cane, rainfall and temperatures both being decidedly below normal. One of the heaviest windstorms of recent years during the early part of the month caused considerable damage, not only to the cane, but to plantation equipment as well. In windward Maui and Hawaii stretches of plantation flumes and trestles were destroyed, causing some delay in plantation operations.

The harvesting and grinding of the 1906 crop is on the whole proceeding satisfactorily.

SUGAR PRICES MONTH ENDING MARCH 15, 1906.

February 15	3.36¢	8s. 0¾d.
February 22	3.36¢	8s. 2¾d.
March 1	3.39¢	8s. 3d.
March 8	3.4375¢	8s. 3¾d.
March 15	3.51¢	8s. 5¼d.

Mr. F. O. Licht in his "Monthly Report" of 16th of February, says:

As we have already made use of the opportunity to remark no tangible idea can be given in figures of the extent of the coming beet area, which can lay claims to reliability, and therefore, for the time one must trust to suppositions which are indeed supported by single facts but, on the whole, have no common basis. As already stated above, the condition of the winter sowing, labor conditions, and weather, will, in the coming time play a part not to be seen beforehand, and as a matter of course the valueing of the sugar as well as the price movement of the agricultural produce in the course of the next months, will have a fairly important influence. The reports at present to hand, speak only rarely of considerable limitations, while in many places, comparatively high offers for sale-beets are reported, and therefore one is inclined to the opinion, that, notwithstanding the unfavorable statistical position, and the very low sugar prices a greater reduction of the area is not to be expected.

COLONIAL AND BEETROOT SUGAR IN EUROPE AND NORTH AMERICA.

In the first five months.	1905-06	1904-05	1903-04	1902-03
Production	5,294,580	3,238,476	4,033,106	3,715,626
Imports	1,582,725	1,582,955	1,317,140	1,528,122
Stocks on 1st September	870,720	1,163,265	1,577,327	1,426,201
Total	7,748,025	5,984,696	6,927,573	6,669,949
Stocks end of January	3,861,464	2,562,951	3,418,522	3,337,513
Deliveries	3,886,561	3,421,745	3,509,051	3,332,436
Exports	1,334,418	934,742	949,118	1,040,951
Consumption 5 months	2,552,143	2,487,003	2,559,933	2,291,485
Previous 7 months	3,065,958	3,633,580	2,908,728	2,944,522
Consumption 12 months	5,618,101	6,122,583	5,468,661	5,236,007

The production of beet sugar during the first five months shows an increase of 2,056,000 tons, against the preceding year. Imports show for Europe and North America together the same number, for Europe alone a surplus of 49,000 tons, while the stocks on September 1st, in Europe and North America together, were 293,000 tons smaller, in Europe alone 350,000 tons smaller, than 12 months previously. From the sum of these 3 groups of figures, there results for Europe and North America together a more of 1,763,000 tons, and for Europe alone one of 1,755,000 tons. At the end of January the stocks in Europe and North America together were 1,299,000 tons, in Europe alone 1,259,000 tons higher, than 12 months previously, and the consumption, taking into account an increase of 400,000 resp. 400,000 tons in the exports, showed during the five months an increase of 65,000 tons, for Europe alone increase of 95,000 tons. But for the twelvemonth ending end of January, there results for Europe and North America together a decrease of 502,000 tons, for Europe alone a decrease of 387,000 tons.

SUGAR MARKET.

Czarnikow, Macdougall & Co., under date of February 23, state:

With diminished offerings from Cuba, for both prompt and deferred shipment, the slightly improved undertone noticed last week has kept up this week, and although no advance can be recorded, there has been no difficulty in placing the small quantities that are in the market at last week's prices, there being more buyers than sellers at the close.

This strength is principally due to the increased disposition shown in Cuba and elsewhere to carry sugars until the prices obtainable in United States are more on a parity with those ruling for beets in Europe. For a time it looked as if part at least, of this disparity might disappear through a decline in the latter, but instead of this beets have exhibited surprising strength and last week's differences of .31c. between the importing cost of beets and the prices ruling here for cane sugars has been increased this week to .34c.

Naturally, Cuba and other cane sugar countries have gathered courage from the firmness of European prices and from an exhibition of strength in a quarter from which they feared a possible show of weakness, owing to the enormous supplies and the lack of relief afforded by predictions of only slightly diminished sowings.

If Cuba had made as much sugar as last year, and weather had favored the gathering of the crop, Cuban planters would probably have gone on selling at 2c. for March, but stocks in Cuba are only half what they were at the same period last year, and rains this week having again interfered with the harvesting, the time lost in December-January is not being made up, while the yield continues very disappointing and much below the normal. This, and fears that much cane will be left on the ground, have caused a better tone in Cuban markets for the time being, and it is not so easy as hitherto to buy in the Island, even at 1-32c. over last week. It is to be hoped that planters will not follow the old game of asking unreasonable prices in the midst of the crop months, but will keep selling a little at each advance, especially for future delivery, and thus avoid forcing lulls in the buying and sudden declines.

European beet markets have had a hardening tendency and close with present crop ¾d. dearer for all months and with next crop ½d. dearer. Quotations are: February, 8s. 1½d.; March, 8s. 2¼d.; May, 8s. 2¾d.; August, 8s. 5¾d. Next crop, October-December, 8s. 7¾d.

Last year the final figures of sowing were much in excess of the early forecasts, and the present strength of the market would seem to indicate an impression that this year's early forecasts may prove at fault in the opposite direction, either this, or a belief that at the current prices the market effect of the enormous stocks is fully discounted.

Willett & Gray in their "Weekly Statistical" of March 1, report as follows:

The chances are that we have seen the lowest prices of the year, and indications point to continued firmness, with a slowly hardening tendency. Even at the advance centrifugals are .29c. per pound below the parity of beet sugars f. o. b. Hamburg, the planters thus giving away nearly all the benefit of .34c. received under the Cuban Reciprocity Treaty, in order to dispose of their early production and obtain funds to discharge their indebtedness for new machinery and new plantings. Some planters have already made necessary financial arrangements and as soon as the others can afford to show firmness, the improvement in prices is likely to become more important.

Receipts at the United States four ports were again 22,000 tons in excess of requirements for meltings, and stocks are increased to 209,249 tons. Stocks in the United States and Cuba together are now 325,249 tons against 364,997 tons at this time last year.

Our cable from Cuba reports receipts at the seaports for the week of 47,000 tons, being 6,000 tons less than for the same time last year, although there are now 179 centrals grinding, against 177, the largest number at work last year.

The smaller production, notwithstanding the fact that all the factories are running and, with improved machinery, is due to the low quality of the juice, the cane yielding about one-tenth less than usual. To date, the visible production in Cuba is 344,000 tons, against 528,000 last year and 408,000 tons in the season before the last and it is a question whether the shortage can be made up before the end of the campaign. There is plenty of cane in the fields, but the dry season will have to be unusually prolonged, in order to give the planters an opportunity to take off all the crop.

Mr. F. O. Licht cables us that weather is unfavorable for field work and that the beet sowings in Germany promise to be only five per cent. smaller than last year. At one time it was thought that there might possibly be 10 per cent. reduction in German sowings, but we learn by mail that 80 per cent. of last year's area had already been contracted for, and there is now no reason for expecting any greater reduction than the five per cent. estimated by Mr. Licht which, with practically no decrease in Austria and possibly 20 per cent. less in France, assures another big beet crop, provided the weather conditions are favorable.

SUGAR DEVELOPMENT IN CUBA.

The interesting extracts from letters from a Cuban sugar planter, give several texts for thought to the planter of Hawaii.

In the first place it betokens the rapid growth of the industry. The plantation described is only one of a number that have been established since the end of the Cuban war.

It is an illustration of what capital can do under adverse conditions, if there is a profit in sight. The moral to be drawn is that if the Philippines secure a free United States market for sugar, capital will as speedily make use of the cheap land of those islands as of Cuba to produce sugar.

In the second place it calls attention to the advanced type of factory that is being installed in Cuba. We flatter ourselves that we are at the forefront in the use of sugar-making machinery; but the enumeration of appliances in this new Cuban mill shows that the Cuban planters have little to learn from us. In fact, it shows that they are ahead of us in some respects—more particularly in the use of juice filters, a process which but few Hawaiian mills are using. It suggests, moreover, the soundness of further investigation along that line. We are informed that several Hawaiian mills are using juice filters effectively and consider them a valuable addition to their plants.

Another rather surprising feature is that French builders of steel buildings and sugar machinery are able to successfully compete with American, German, Scotch and English manufacturers, furnishing better material for less money.

THE EXPERIMENT STATION REPORT.

The Experiment Station Report for February contains the following digests:

The Culture of sugar cane and the sugar industry in Hawaii and Reunion, L. COLSON.—In discussing the culture of sugar cane, the soil, planting, use of fertilizers, irrigation, cultivation, yield, varieties of cane, rotation of crops, labor, cost of production, methods of transportation, experiment station work with sugar cane, and planters' associations are considered.

Descriptions of a number of plantations and sugarhouses are also given. Much of the information presented is compiled from bulletins and periodicals published in the Islands. The discussions on the manufacture of sugar treat of the methods and systems of machinery employed, the yields of sugar, uses asd value of the by-products, and the cost of production.

Vanilla culture in the Hawaiian Islands, A. INKERSLEY.—An account of planting about 8000 cuttings of vanilla in the region of Kona, Hawaii, where it is believed the climate is especially suitable for this crop.

BEET SUGAR INDUSTRY.

HOW CONDUCTED, AND VALUE OF BY-PRODUCTS IN GERMANY.

Consul Diedrich, of Bremen, furnishes a report on the production of sugar beets in Germany, giving the extent and value of the by-products in their conversion into sugar. He writes: The importance of the sugar beet culture in Germany does not rest wholly upon the production of the beets which furnish the raw material for the production of sugar, but in no small measure also upon the production of large quantities of by-products that are mainly used as feed stuffs. It has been well said the profit derived from feeding the waste products of the factory and those parts of the beets left in the field are almost as great as the profit from the manufacture of sugar. The leaves and tops of the beets as they are garnered are a very useful waste product, their feeding value in this country being about $2.85 to $3.57 per 0.630 acre; but very frequently they are given to the farmers who pull the beets, top them, and pile them up, or pit and silo them in the field, in lieu of wages.

RESIDUUM PULP AND ITS USES.

Of still greater importance is the residuum pulp left after the sugar has been extracted from the beets. It amounts to about 50 per cent. of the tonnage of beets sliced in a factory and makes a most admirable feed for all kinds of stock, but it requires considerable care and judgment in feeding it properly. It can be stored in silos and kept for months for feeding purposes, but it is more generally evaporated, and when thus dried becomes not only less perishable, but is made more useful and marketable. However, as the process of evaporating pulp in factories specially built for that purpose, with costly machinery, is a very expensive one, dried pulp has not yet become very popular. It is commonly estimated that 900 kilograms of fresh pulp will make about 100 kilograms of dried pulp, the market value of which was, during the past year, \$1.90 to \$2.62 per 100 kilograms. It is the rule at German sugar factories to deliver a part of their fresh pulp to the farmers supplying the beets at the ratio of about 40 to 50 per cent.—that is to say, if a farmer hauls one ton of beets to the factory he takes home with him about one-half ton of pulp without any extra charge. It must be added, however, that the farmers in such cases are also shareholders in the factory. The balance of the pulp is either fed to the stock belonging to the factory or sold in the open market. The price paid varied from 12 to 42 cents per 100 kilograms.

QUANTITY AND VALUE OF MOLASSES.

The molasses residue finally left from beet-sugar factories, after being thoroughly desugarized by one of the various patented processes, is of a very low grade and may then be turned to many uses in different industrial enterprises, such as the making of potash, blacking, vinegar, yeast, dyestuffs, etc., but by far the greater part of it is utilized in Germany in the manufacture of alcohol, and last, though not least, also as a stock food. However, this molasses is not fed alone, but always with the admixture of pulp or some other fodder to counteract the evil effects that it otherwise is apt to have, especially on cattle. Very often it is mixed with turf taken from the upper strata of peat moors, which in itself has no feeding value whatever, but when so mixed it is claimed that it is a cheap and wholesome substitute for the best approved foods for animals. During the past year the price for molasses averaged about \$13.09 to \$14.28 per ton. The amount of molasses produced during the past two years was 392,019 tons in 1903-4 and 371,093 tons in 1904-5. Up-to-date statistics are scarce in Germany, but it is now known that in 1903-4 226,570 tons of molasses were desugarized, 36,312 tons were distilled into alcohol, and 129,137 tons were used as feed and for other purposes. There is absolutely no waste in the beet-sugar industry in this country. Even the settling of lime, and of the dirt and soil dropped from the beets while they are being washed, are either given away to the farmers or sold to them at 2½ to 31 cents per 100 kilograms for the former and half a cent for the latter, and both serve as excellent fertilizers.—Consular Report.

During 1904 Cuba had, according to an American publication, 174 plantations which were owned, 69 by Cubans, 64 by Spaniards, 24 by Americans, 9 by British, 7 by French, and 1 by Germans.

EXTENT OF SUGAR BEET SOWING FOR 1906.

By Sigmund Stein.

The question of the extent of beet sowing in the coming season occupies the minds of all the sugar merchants, brokers, and sugar consumers in general.

After the year of drought in 1904, one of the leanest years ever known in the production of beet sugar, came a year of superabundance, the season of 1905. The acreage of sugar beet sown in 1904 was 3,980,358 acres, and in 1905 4,643,037 acres. The production of beet sugar in 1904-05 was 4,706,900 tons, and the quantity to be produced during the present campaign (1905-06) is estimated at 6,875,000 tons. There will certainly be a surplus of sugar on the 1st of September, 1906, to be carried over to the campaign 1906-07, which will amount to 2,200,000 tons.

We must not forget that the over-production of cane sugar keeps pace with this over-production of beet sugar. In the same degree that the beet sugar manufacturers try to extend the capacity of their works, in the same measure does the cane sugar manufacturer extend his capacity for working from season to season, so as not to be left behind. The consumption, however, cannot increase in the same proportion.

Since the abolition of sugar bounties and the coming into force of the Brussels Convention, 1st September, 1903), the consumption of sugar in Continental countries has increased greatly. This increase, however, will shortly cease, as people on the Continent are not accustomed to consume such a quantity of sugar as we do here in England, or as is done in the United States of America.

How will the matter end? What is to be the outcome of the sugar produced? Sugar is not an article that can be stored for years, on account of its bulky character; and another thing not to be lost sight of is the interest on the capital. We face today the same conditions as we did a few years ago, and I raised my voice then and wrote frequent articles warning beet growers and cane planters and sugar manufacturers to be very careful in the extent of their operations. The outcry raised at the time by shrewd persons, and the warnings given by experienced men, were taken into account and had their effect. The acreage of beet sowing and cane planting was reduced after a season of overproduction. Yet how long is sugar to be sold under the cost of production? How long will manufacturers and growers throw their ready money through their factory windows? Is not the policy of not producing at all, and shutting the factory doors, better, than keeping the works going day and night, suffering any amount of trouble and in the end showing at the close of the season a large deficit, a crowd of disappointed shareholders, and a very unsettled state in the markets?

After the over-production of 1905 it was the belief amongst all classes that the next year (1906) would bring us a great reduction of beet sowing and cane cultivation. Yet, when I was on the Continent a few days ago, I noticed to my great surprise the contracting of beetroots at a price which shows at only a superficial calculation a great loss to the manufacturers. I saw prices of 95 pfennigs to one mark per cwt. were being offered to and accepted by the farmers. Everybody who has acquired only a rudimentary knowledge of this industry ought to see that there was a loss when this contract was made. I have heard that some contracts have been made at 75 to 80 pfennigs, but I have been assured that the level of 90 pfennigs to 95 pfennigs was offered on the average.

It is true that the manufacturers have works to keep up, and they wish to keep their concerns going, but they can do so even if they do not work up to the full capacity of their factories. If they curtail their working capacity by 25 to 30% they will still work at a profit if they can force the sugar beet grower to reduce his sowings to a similar extent. The price of sugar is regulated by the supply and demand. If again there be too much sugar produced next year, prices must remain as they are or fall still lower. In that case, there is only one remedy for bringing people to their senses, and that is bankruptcy.

Continental manufacturers had on an average a good year in 1905, and the prices in January of that year reached a level not attained for 17 years, and they naturally made proper use of the high prices and sold at a handsome profit. They did not consider that this profit is only the natural consequence of the drought of 1904 and the subsequent nonsensical rise in price. They did not consider that this *coup* will not be repeated again, that the "corners" in France will never be re-established, and that the world in general has taken a good lesson from the smashes of last August and September.

The thundercloud I prophesied in this paper just a year ago came as I said, and many people have been buried under it, who, in their foolish and selfish policy, thought that they were wise and that their calculations would be adopted by the rest of the world. I give now a few words of warning, the same as I did twelve months ago. If only the large sugar societies on the Continent would take the matter in hand and organize amongst their members a plan for reducing the quantity of sugar beet to be sown and contracted for next season, and if cane planters would follow suit and only produce the quantity which will correspond with the consumption, we should soon see prices profitable to the grower and the manufacturer, and acceptable to the consumer.

SUGAR MILL DEVELOPMENT IN CUBA.

Since the Cuban war was ended a number of new sugar plantations have been established by Americans in Cuba.

A high class of machinery is being installed and developments pushed with great rapidity. A resident of the Islands recently received from the manager of one of these plantations two letters setting forth what was being done.

A mill was being erected with the capacity of 125 tons a day. The erection of the mill was begun on the first day of May and completed at the end of December, 1905, ready to take off the first crop, which consists of 3300 acres of plant cane, besides a considerable quantity of cane bought from outsiders.

The detailed description of the factory and its equipment is of such interest to all connected with sugar that we have the following extracts from the letters indicated:

............, Cuba, May 3rd, 1905.

As you know we are erecting a sugar mill here. The machinery consists of:

A crusher and 9-roller mill supplied by an American firm; 5 600 H. P. "Climax" boilers, furnished by the Rowland Company of Stockport, England; and a sugar house proper, built by the Fives Lille Company of France who easily defeated everybody else in the question of prices and quality of material.

The sugar house contains: Three liming tanks placed on the ground floor; 8 defecators, placed on a level with the pans, 10 metres from the ground; 4 tanks placed just below them and above the Daneks, for neutralizing the clarified juice before filtration; 10 Danek filters; 8 large filter presses, total area about 7000 square feet of filtering surface; 12 crystalizers, 1000 cubic feet capacity each; 14 water-driven centrifugals; 2 13-inch pans, and 1 air pump, which does the whole business.

We have separate condensers for the pans and the quadruple effect: the latter has about 18,000 square feet heating surface and is of standard vertical type with brass tube sheets.

The Danecks filter presses, juice heaters, and crystalizers are all on one floor 4½ metres from the ground. The pans and defecators are on another floor 5½ metres above; all the moving machinery is on the ground floor with the centrifugals. We are using extensively belt-driven centrifugal pumps driven by one large engine for pumping liquor to the various stations, and I think we have reduced the steam cylinders in the house to very nearly a minimum.

An American firm has the contract to get out the building to contain the mills and boilers, and to purchase the feed pumps, blowers, and bagasse carriers, etc., which are contained in that building. The Frenchmen furnish their own building and put it up and all the machinery in it.

As you may probably infer, the placing of so much of the machinery outside of the United States was a great surprise to very many of the old-stagers here, but we went to the best people, without any doubt.

We have about 100 caballerias of spring cane immediately surrounding the sugar house, (1 caballeria=33 1-3 acres) and will have a considerable quantity of old cane from outsiders on the line, for the first crop. We will, of course, shortly start in on our fall planting.

ARRANGEMENT OF SUGAR HOUSE.

The sugar house is arranged in such a way that the first sugar may be dropped directly into the mixers above the centrifugals, or may be taken into the crystalizers, as we desire. I have got a crystalizer with an arrangement for stirring in it which I think is the best in the market; the scroll shafts inside working conically within each other and apparently giving better and more uniform mixture than any other scheme. The pans may be emptied into the crystalizers by suction, i. e., break the vacuum on the pan and put it on the crystalizer, and in that way hurry the discharge of the pan very materially. The crystalizers may also be emptied by using compressed air, although they can empty themselves by gravity. I am going to make a serious effort to handle the first sugars in the crystalizers, and at least to find out where we stand in this matter; I rather suspect that Cuban massecuite can be handled this way, although it does not appear to succeed in other countries.

FRENCHMEN CLOSEST BIDDERS.

Specifications and prices were obtained from American, Scotch, English, German and French firms. The result was never in doubt as regards the prices, but at first we thought the French specifications (which were not very detailed) could not be equal to the Scotch or American ones; a close investigation, however, showed that we were getting heavier copper in our pans, heavier steel in our buildings, and better worth all around from them than from anybody else. They were anxious for the job, and on account of their great capacity could make prices that knocked the others out.

RECORD BREAKING CONSTRUCTION.

November 15, 1905.

We have done something towards breaking records here in the way of erection. We would have been nearly finished now had it now been for delays in the Santiago Custom House—a wholly unexpected difficulty; nearly everything has been held up from a month to five weeks in that infernal port. We utterly refused to countenance anything in the shape of golden ointment, which you know was so efficacious in Spanish times, and I am fairly well convinced that lack of lubrication has had a great deal to do with our troubles. Our old friend .... is Chief Appraiser, and I think he is perfectly straight, but below him are many and above him a few to whom it must be very unpleasant to see three or four hundred thousand dollars worth of machinery pass through their hands without leaving a grease mark of any kind. We have everything on the place now except our last cargo, which has been thirty days in Santiago and which we hope to receive at any time.

FRENCHMEN MADE GOOD.

You will be interested to know that the Frenchmen have made good in every particular. All the machinery they have sent is first rate in every way. The roofing and siding of the building is about No. 18 corrugated iron and is all put on with belts and straps. The coils in the pans are the finest I ever saw—in fact they have done their very best for us, and have undoubtedly given everybody an object lesson in swiftness of erection. They erected the first post of their building about the 1st of September and had it all up in about three weeks, including the floors for the pans, crystalizers, filter presses, etc., and all the centrifugal plant. They were then held up some time for machinery, but in spite of that have got everything up now except one pan and the bulk of the piping. It looks as if they would finish before December 15th.

The mills made in the States, seem to be a good job—the shafts are of nickel steel, oil tempered, and so are the king-bolts, journal bearings phosphor bronz 18x24 and 16½x24.

ABOUT CRYSTALIZERS.

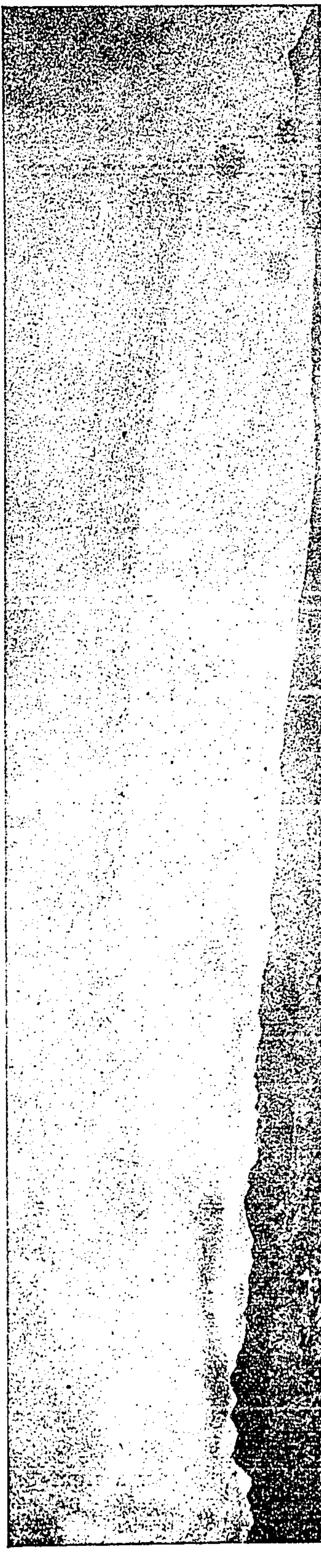
I would be very glad to hear from you about work with crystalizers. I note that you think it is wise to put first sugars into crystalizers, and in designing this house I carefully arranged to be able to use the crystalizers in any shape for anything. They are placed well below the pans and have a suction pipe from them so that we may put the vacuum on the crystalizers after breaking it on the pan, and draw the contents in. We also have compressed air connection for discharging them into the mixers above the centrifugals. I shall, of course, start putting only seconds into the crystalizers, but I am not determined whether to boil the molasses to a grain, i. e., starting the grain in them by drawing in first liquor, or to drop them blank at a string proof and a low temperature and trust to the grain forming in them. We shall probably only make first sugars, and remelt all our second sugars—at the present state of the sugar market.

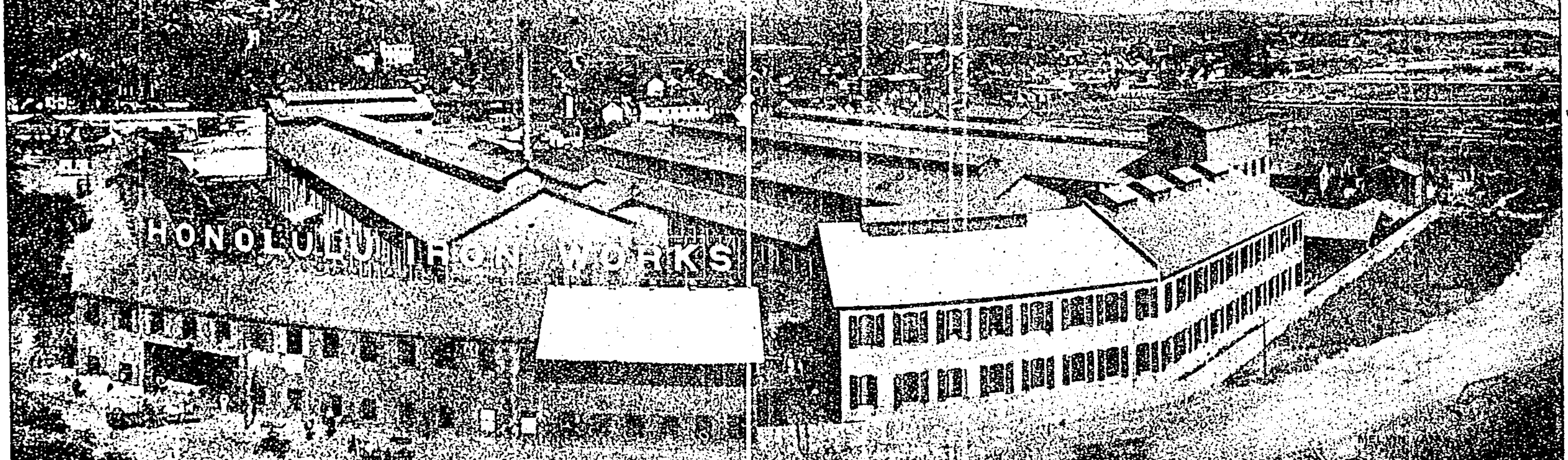
HONOLULU IRON WORKS COMPANY, HONOLULU, HAWAII.

The Honolulu Iron Works Company was established in 1853 by Mr. D. W. Weston, the inventor of the suspended centrifugal machine now used in almost all sugar factories. It was first incorporated December 22nd, 1856, and re-incorporated December 22nd, 1896, at which time nearly all the Sugar Factors in Honolulu became stockholders; and new modern works were erected on land acquired near the harbor front.

The works occupy six and one-half acres of ground and consist of Machine, Moulding, Boiler, Blacksmith, Carpenter, Pattern and Coppersmith Shops, all of the most modern and approved type, equipped with hydraulic, electric, steam and compressed air powers; and with twenty ton electric traveling cranes of sixty feet span in all of the principal shops. All the buildings were built and erected by Messrs. Milliken Bros., of New York; they are constructed entirely of structural steel material and the three main shops are each 300 to 400 feet long and 90 feet wide. The number of employes varies from three hundred and upwards; there are about eight draughtsmen, and a staff of about fifteen to twenty clerks and store keepers.

The large majority of all the new machinery installed in the Hawaiian Islands sugar factories has been manufactured by the Honolulu Iron Works Company, and almost all repairs to plantation machinery, pumping plants, steamers and ships, including United States war vessels, have been executed in its shops, thereby excluding almost entirely foreign competition, principally on account of the excellent workmanship, better knowledge of exact local requirements and reasonable prices. While about a dozen modern mills (crushing plants) of foreign manufacture are at present working in the Islands, the Honolulu Iron Works Company has over thirty modern nine-roller mills of their manufacture in operation, five twelve-roller 34x78 mills, and a num-




HONOLULU IRON WORKS

ber of older types of mills. Besides having built the majority of the machinery in the old factories, they have since 1898 contracted for (and wholly, or partially, designed and built) the following large modern complete sugar factories in the Hawaiian Islands. The noted cane capacities per diem may be considered present averages, as the various mills are worked with different speeds according to the methods used in the factories, supply of cane, grinding hours, duration of crops, etc.

Oahu, 1450 tons; Waialua, 1000 tons; Ewa, 2000 tons; Olaa, 1100 tons; Puunene, 2400 tons; Puako, 200 tons; Hawi, 350 tons; the first five are arranged, as far as the buildings are concerned, for considerable increase in the capacity.

Besides the above, one new factory and modern distillery with an initial capacity of 1200 tons of cane per diem, is now being constructed by the Honolulu Iron Works Company for the Oaxaquena Plantation in Mexico, and a complete sugar factory with a daily capacity of 1200 tons of cane for Wailuku Sugar Company, Maui.

As the Honolulu Iron Works Company is located near the plantations, executing almost all their repair work, and building practically all of their machinery of whatsoever nature, except such installations as centrifugals, small pumps, electric plants, and other specialties, it is reasonable to expect that they must have an exceptionally good knowledge of the special requirements of sugar plantations and the proper working of their machinery. It is, however, principally due to the progressiveness of the various mill managements and the efficient and extensive chemical control in the principal Hawaiian factories that the losses in the various branches of manufacture are being determined and gradually greatly reduced by the introduction of improved methods and machinery.

In connection with the manufacturing departments of the Honolulu Iron Works Company there is also an extensive Merchandise Department, carrying stocks of heavy and light hardware, besides general engineering supplies, plumbing goods, oils, etc. The general offices, as well as warehouses connected with this dpartment, are located in Nuuanu Street, facing Merchant Street, and occupying nearly two acres of land.

In May, 1905, the Honolulu Iron Works Company established an Eastern Branch Office in New York City, located in the Bowling Green Building, No. 11 Broadway, Rooms 1113, Telephone No. 5332 Broad. This office is in charge of Mr. D. A. Fox. The principal object of establishing this office is to enable the Honolulu Iron Works Company to purchase direct from the manufacturers all the raw material, finished machinery and engineering supplies, etc., used in their Hawaiian Islands business. There is also connected with this office an engineering bureau wherein are employed the most experienced and competent engineers and draughtsmen, who attend to such engineering work and contracts as the Honolulu Iron Works Company is engaged in in that part of the country.

The resident agent of the Honolulu Iron Works Company in the Philippine Islands is Mr. C. B. Ripley, Paris Building, Escolta, Manila, P. I.

Some sugar machinery has been built for sugar plantations in Formosa and work has been manufactured in the shops for a Sugar Refinery in California.

The present officers of the Honolulu Iron Works Company are:

Mr. F. M. Swanzy (of Theo. H. Davies & Co., Ltd.) . . President
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SUGAR PLANTATION PESTS.

By R. C. L. Perkins.

During the summer of 1904 the Hawaiian Sugar Planters' Association appointed a staff of entomologists to form a division of entomology in connection with their prior established experiment station at Makiki, providing fully equipped offices, a laboratory, library, and all the necessaries for scientific work.

This association has always given liberal financial aid to the Territorial entomologists of the Bureau of Agriculture, but the serious loss to the sugar industry occasioned by an imported insect on various plantations, rendering it necessary for the entomologists to give their undivided attention to this pest, largely brought about the establishment of the division of entomology above mentioned.

Such undivided attention could never be given by the entomologists in the Territorial offices, who are naturally subject to inquiries from the public for information and advice on all manner of insect pests, many of these being comparatively of quite trivial importance.

In May of last year Mr. Albert Koebele, accompanied by the writer, visited Australia in search of such predaceous and parasitic insects as might be found to attack the above-mentioned insect pest of the sugar cane, with a view to importing them into these islands. About six months were spent mainly in this work, and an extensive study was made of many leaf hoppers, to which class the pest in question belongs, and the natural enemies that keep them in check. Every two or three weeks living predaceous insects or parasites, such as attack or might attack the sugar cane leaf hopper, were sent to the islands to be tended by the resident members of the staff.

It is gratifying to know that several of the leaf hopper enemies are now fully established here, and all are in the way of being distributed to every plantation on the several islands. As far as time permitted, attention was also given to beneficial insects which would destroy some other of our imported pests, such as various scale insects, hornfly, etc., and many were sent to the islands for this purpose.

It is now possible for the many plantations to be visited and thoroughly inspected by competent entomologists at regular intervals; and full records are kept as to the abundance or otherwise of insects beneficial or noxious on each plantation. The publication of the results of the Australian mission will, it is expected, be completed within a few months, the work on the material collected being already far advanced, and it can not fail to be of great scientific interest as well as of practical use.

IMPROVEMENTS OF SUGAR CANE BY SELECTION AND HYBRIDIZATION.

By F. A. Stockdale, B. A.,

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

Probably no subject is of so much importance to planters of sugar cane as that relating to the introduction and trial of new varieties. It would appear that the first announcement respecting the possibility of raising seedling canes in the West Indies was made at various times between 1859 and 1888.* A similar announcement was made in Java in 1887. Since 1888, their cultivation has been intelligently followed up and much improve-

*Harrison: *Kew Bulletin*, 1888, p. 294.
Morris: *Journal Linnean Society*, XXVIII (1891), p. 197, plate 33.

ment in the sugar cane has resulted. Varieties have been raised which are capable of resisting, to a large extent, attacks of disease which destroyed the older forms, and this has led to a demand, still imperfectly satisfied, for the better kinds of canes. 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. The variety oi soil and climatic conditions of the West Indies render it necessary to have many kinds of cane differing in their requirements, for it could not be expected to produce one single cane to suit all situations. Several experimental plots, in the different islands, were started to produce better canes, and the success of the results obtained must be very gratifying to those who have spent much time over these experiments, for the seedling canes produced in Barbados by Mr. Bovell and Professor Harrison, and by Mr. Janman and Professor Harrison in British Guiana are now well known in most of the sugar-producing countries of the world. In striving to produce improved kinds of canes many features must be taken into account, amongst which the most important are: their germinative power, behavior under excessive dryness or moisture, resistance to disease, ratooning power, milling qualities, fuel-producing property (depending on the percentage of fibre), quantity of juice and the productive yield of sugar. The last of these features is, no doubt, the one which claims the most notice, for maximum productiveness in most cases has not yet been reached and much is still to be gained in this direction.

The earlier method adopted for producing seedling canes was the careful selection of casually produced seedlings. A later step was the identity of seedlings from the seed-bearing parent. A further stage was raising seedlings from canes planted in alternate rows so that the pollen-bearing parent might be identified as well as the seed-bearing parent. Experiments in this direction have been carefully carried on at Java, Barbados and British Guiana.

The selection method practiced in British Guiana was well described under separate heads by Professor J. B. Harrison at the last West Indian Agricultural Conference (see *West Indian Bulletin*, Vol. V., p. 337) as follows:

"*First selection* of parent varieties for seed producers;

"*Second selection* of the more vigorous of the seedlings obtained from them for field propagation;

"*Third selection* of the varieties growing under field conditions by the cultural characteristics;

"*Fourth selection* from these selected sorts by their analytical characters;

"*Fifth selection.* The third and fourth methods are repeated with plants raised from tops of the varieties selected under the fourth selection, and this is done repeatedly during their cultivation from plants to second and third ratoons. As the method of cultivation in British Guiana renders it necessary for canes to have good ratooning powers to be of service as sugar producers, we lay more stress on the selection from ratoons than from plants;

"*Sixth selection.* These varieties, which have been selected, are next grown on plots of about 1-20 acre, side by side and under identical conditions of cultivation and manuring. On these their peculiarities are carefully watched, and out of batches of forty or so selected for this trial probably not more than a dozen will be retained in cultivation as third or fourth ratoons;

"*Seventh selection.* During the course of the fifth and sixth selections, several of the varieties finally retained in cultivation will have been selected by planters by large-scale cultivation. These and a few others selected by ourselves are next examined by means of manurial experiments. Plots of about one-half acre are divided into smaller plots, and upon these the varieties are raised under varying systems of manuring. Some of the plots of every kind are manured with phosphates, and perhaps potash, others are not. Some of each are grown without any nitrogenous manures, others with increasing quantities of nitrogen. It has been found that the mean results of a kind under the varying kinds of manuring apparently offer the most reliable figures as to comparative value we can obtain on small-scale experiments."

In Barbados, the selection of seedling canes, similar to that of British Guiana, has been practiced for some years. Recently, however, an effort has been made to reduce the time in selecting seedlings by two years, by means of irrigation. The method adopted is as follows:

After the canes are pricked out into pots and grown to about one foot in heigh, they are planted in the field during April and May of each year and irrigated. The following May, the canes are first of all selected for their field characters, and then crushed and tested for their saccharine content. The stools of those canes which are rich in sucrose and have given a heavy tonnage are taken up, divided in half, and replanted under irrigation. The following December the canes from these stools are cut up and planted in the experiment plots to start their career in the successive stages of selection until the best of them—generally a very small percentage—attain the standard of being tested on acre plots.

At the Barbados and other experiment stations, the canes are grown under the ordinary conditions existing upon the estates where they are cultivated. The plots in which the seedlings are grown are arranged in duplicate. Each plot consists of 100 stools of canes arranged in four rows of twenty-five. For planting the next year, the canes from the outside rows are utilized; whereas, the inner thirty stools are cut, weighed, and sampled. By recording the results from the inner rows only, the effects of one variety upon the growth of another and less vigorous variety are therefore eliminated. One hundred pounds of each sample are then crushed in the laboratory mill, the juice and megass weighed, and the juice analyzed, from which data the results are calculated to the acre.

By means of this rigorous selection several good varieties have been raised, but a large percentage of the seedlings thus produced have proved to be worthless. The fixing of the good varieties is rendered easy, as plants raised from cuttings come true to the parent and do not necessitate, therefore, additional selection year after year. By this means thousands of seedlings have been raised every year, and after careful trial on experimental plots in different parts of the West Indies for several years in comparison with standard canes, the best are selected and recommended to planters for final trial under estate conditions. It therefore takes several years before a seedling cane has been sufficiently investigated to deserve recommendation to the planters, and then it must be left to the planter finally to select those which he thinks suitable for his cultivation, as a seedling may give very good results in one soil but prove an utter failure in another.

The difficulty, however, that had to be contended with by this method was that, although the seed-bearing parent was known and registered, the male parent was unknown, and therefore a vast majority of the seedlings were less valuable than the seed-bearing or female parent form originally selected. With a view to reducing this difficulty to a minimum, crossing has been resorted to, in the hope that some of the offspring will combine the good qualities of the two parents.

By this means, both parents are carefully selected, both have to be high in saccharine contents, and both have to possess good field characters. Hybrids generally possess a more vigorous growth, which provides suitable conditions to make it possible to obtain advantages resulting from the mingling of ancestral plasma-masses. Therefore, by hybridization, it is hoped to combine some of the desirable characters of both parents and therefore produce canes which can be highly recommended.

The first method by which hybridization was effected in the West Indies (and here it was that the first systematic attempt was made to obtain hybrids of sugar cane) is what might be called the natural method. Two good varieties known to arrow at the same time were planted in adjacent plots. Owing, however, to a large number of varieties being under cultivation, it was found almost impossible to ensure against the risk of pollen coming from an unknown source, and therefore this method had to be modified.

The next method adopted was to plant varieties arrowing at the same time side by side in alternate rows, so as to present a chess-board pattern, and the cross-pollination left to chance. Some of the seedlings must have been produced from the parents by fertilization *inter se,* and a certain amount of uncertainty must exist as to the parentage of the resultant seedlings.

The Hon. Sir Daniel Morris, K.C.M.G., Imperial Commissioner of Agriculture for the West Indies, suggested another method for the hybridization of the sugar cane, which is much more practical than those formerly used. Each arrow under experiment is bagged some time before it is ripe and when the pollen reaches maturity the contents of the bags of one variety are shaken (through temporary openings) into the bags of another which is to be the female parent. If precautions are taken to prevent the access of foreign pollen, this method is a good one and can easily be carried out.

A great advance, however, was made in the hybridization of the sugar cane, when it was found that certain varieties do not produce fertile pollen, while their pistil is normal, whereas other canes produce a large amount of normal pollen. A great number of the better seedlings of Barbados were examined in the laboratory of the Imperial Department of Agriculture for the West Indies, and the investigations have enabled us to divide these seedlings into three classes: (1) in which the anthers show a large proportion of normal pollen; (2) in which the anthers show a very small proportion of normal pollen; (3) in which the anthers show a moderate proportion of normal pollen.** If, therefore, an arrow of a cane producing much normal pollen is bagged, with an arrow which produces little fertile pollen, the risk of self-fertilization is reduced to a minimum, and if fertile seeds are produced by these canes, they will almost certainly be the result of hybridization.

The method now practiced is a purely artificial cross-pollination, in which the flowers of one variety are emasculated, while still young, and then pollen is transferred from another variety by means of a camel's hair brush to those that have been emasculated. This experiment was successfully carried out by Mr. Lewton-Brain (now Assistant Director of Vegetable Pathology, Hawaiian Sugar Planters' Association) in November, 1904, when he was Mycologist on the staff of the Imperial Depart-

*d'Albuquerque: "Notes on Artificial cross-fertilization of Sugar-cane.' *West Indian Bulletin*, Vol. I, pp. 182-4.

Kobus: *Revue des Cultures Coloniales*, T. VIII, 1901.

**Lewton-Brain: "Hybridization of the Sugar-cane." *West Indian Bulletin*, Vol. IV, pp. 63-73.

ment of Agriculture for the West Indies. He worked with some of the best of the Barbados varieties and obtained five seedlings, which proved that the raising of hybrid sugar canes by artificial cross-fertilization is practicable. These are the first seedings raised in the West Indies whose parentage is a matter of certainty. They are being carefully propagated, and instructive results are expected to follow. The method adopted by Mr. Lewton-Brain is described by him in the *West Indian Bulletin* (Vol. V., pp. 362-3) as follows:

"A strong, movable platform was constructed, eight feet high, the top being six feet by four feet. On this, there were boxes of different sizes, which served as tables and stools of varying height. The stamens were removed under the dissecting microscope, and the chief difficulty was found to be that of keeping the spikelets steady under the lens while the work was going on.

"Arrows which were just beginning to emerge from the upper leaf-sheath were always selected. The cane was bent over carefully to the table, and tied firmly to neighboring canes and to the platform. The lower part of the arrow was placed in a clamp, the foot of which was then screwed into the top of the platform. All this had, of course, to be done with the greatest care, so that no undue strain was put upon any part of the cane.

"The table and dissecting microscope were then shifted into as convenient a position as possible, and the stamens were removed from about a dozen to twenty spikelets, perferably on several branches of the arrow. This operation proved to be one of some difficulty and delicacy under field conditions; frequently the stigmatic plumes were removed or injured before the third stamen could be got out. It was found necessary to work with one's back to the sun to avoid the glitter from the glumes and hairs.

"The remaining spikelets on the arrow, including, of course, all those that had emerged into the air before the operation, were then removed.

"Meanwhile a strong pole, sixteen feet high from the ground, had been fixed near the base of the cane. To this, near the top, was fixed a wire cage, sufficiently large to include easily the whole arrow; the cage was made in two halves which were left sufficiently apart to admit the arrow. The cane was now gently and gradually released and the arrow brought into the cage; this was then closed and covered with fine, strong muslin. The whole was sewn up carefully, and the cane and arrow tied up to the pole; in some cases, too great a strain was put upon the upper part of the cane in the tying, and the arrow dried up. A few days later, when the stigmatic plumes were seen to be turning red and opening out, pollination was performed, and the muslin again sewed up.

"The whole process is tedious and one that requires great care and delicacy at every point. Under the conditions, this is not always easy. Even then, a sudden gust of wind or a sudden shower of rain may spoil a morning's work."

In view of the success of this work, it was decided this year (1905) to commence systematic attempts to raise new hybrids. Owing to fluctuating variations in some of the new seedlings, only those which had stood the stringent tests on a large scale for a considerable time, were used in the experiments. Of these, B. 147 and B. 208 were considered the best, and over 400 spikelets of these two varieties were emasculated and pollinated. The method adopted was practically similar to that described above, there being a few slight practical deviations. The staging was made one foot higher so that the cane under experiment did not have to be bent so much from the upright position. 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 examinations 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. The numerous spikelets are generally arranged in pairs, one being sessile and the other stalked. The sessile spikelets are much larger than those on the stalks, but the slightest touch removed them from the spike, so that most of the work had to be performed on the stalked spikelets.

Three sound canes were chosen from the varieties to be used, and at least a dozen spikelets in each arrow were operated upon. Two or three spikelets were left on each spike in order to distribute those emasculated throughout the arrow. The emasculated arrow was then tied securely to the pole and brought into the cage covered with strong muslin. The pollen-bearing arrow was then cut off and a portion of it tied with the cut end in a bottle containing water to the pole, which was erected to support the cane. By this means, it is possible to keep the pollen-producing arrow alive for from two to five days and therefore produce a constant relay of fertile pollen for pollination. When the stigmata appeared, each of the spikelets emasculated was pollinated twice by means of a camel's hair brush, a separate brush being used for each variety.

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. Over 600 spikelets have been emasculated and artificially pollinated this year, and it is hoped that the results obtained may be such as will before long be appreciated by sugar planters. A concise account is being kept of the crosses performed, and next year it is hoped that a series of investigations with the cytology of the sugar cane will be carried on, with a view of obtaining, if possible, the right age for pollination.

Experiments have also been carried on by Professor J. P. d'Albuquerque and Mr. J. R. Bovell in Barbados, Professor J. B. Harrison in Demerara, and Dr. Francis Watts in Antigua, with the object of ascertaining if a higher saccharine content of a certain variety can be induced by repeatedly selecting plants from the richest plants of that variety. This is usually referred to as chemical selection. The results so far obtained appear to be conflicting, but it seems that a greater yield of sugar will only be induced by careful crossing of the better varieties.

It is now certain that a class of canes has been raised in the West Indies that possess not only a greater sugar-producing quality than the older varieties, but also possess, to a large extent, those qualities which enable them to resist disease, so that the planters are now able to override the obstacles which occurred in the cultivation of the older varieties.

The first object for which seedling canes have been raised has, to a large extent, been accomplished, for these new varieties have now been tested in different localities for a sufficient period of time to demonstrate their disease-resisting qualities; and therefore we now have to turn to the other qualities which go to form our ideal. In the selection of varieties for crossing, the sugar-producing capacity is all-important, but considerable notice should be taken of the field characters, especially when it is generally known that planters have a great objection to many canes, because they do not present a pleasing aspect when in growth.

The introduction of these new seedlings in the West Indies has been fully appreciated not only here, but also in other parts of the world, for Barbados and Demerara seedlings have shown that they are superior in many respects to the home canes in such sugar-producing countries as Louisiana, Queensland, Hawaii and Cuba.

The Bourbon cane was formerly the standard cane in the West Indies, but the results of experiments with seedling canes on a large scale "indicate an increased yield per acre of from 12 to 20 per cent. over that of the Bourbon." The seedlings that are best known in most parts of the world are D. 109, D. 74, D. 95, B. 147, and B. 208.

The last two mentioned have successfully stood the test for many years on an estate scale all over the West Indies and present many characteristics which make them worthy of special mention. This year the crossing of these two varieties has been performed, and it is hoped that not only will a good variety result, but that data will be obtained which may prove useful in helping to trace the dominant and recessive characteristics of each variety, when these crosses are allowed to fertilize themselves.

Several arrows of the better of our varieties are being bagged separately so that they may fertilize themselves, and therefore the resultant seedlings will give some clue to the more prominent characters of these varieties, and will be of assistance in the further crosses that will be made.

The planters in the West Indies freely express their appreciation of the advantages that they have derived from the introduction of these selected varieties and feel that they are now in the possession of a powerful defense against many forms of cane disease.

In Demerara, up to the beginning of 1905, nearly one-third of a million of seedling canes had been raised by the selection method, and 26,000 of these had been selected for field experiments. A few hundred have been selected from these for continued experiments, and practically every estate in the colony has its experimental plot. It need only be stated that at least 12,000 acres are being cultivated in new seedling varieties, to show that planters fully appreciate what has been done for them in the matter of new varieties of canes.

In Jamaica a large number of seedlings have been successfully raised and several others have been introduced. B. 208 is extensively cultivated on an estate scale, and it is now evident that the splendid qualities of this cane are the outstanding features of the trial plots there, for it has given nearly double the quantity of canes per acre produced by the older kinds.

In Barbados during the last five years over 20,000 varieties of seedling canes have been raised and planted out, but less than one per cent. of these have stood the stringent tests of field and chemical selection applied to them. Seedling canes were brought into early prominence here owing to the failure of the Bourbon cane through attacks of fungoid disease, and they have shown that they are capable of considerable resistance to attacks of disease and at the same time give a larger yield of sugar per acre. Many of these seedlings have been distributed to other West India Islands.

The Hon. Dr. Francis Watts in Antigua states that "by means of the introduction of new varieties of canes the planter has now an opportunity of selecting his canes for particular soils and situations. In this way, he may not necessarily select that cane which has done best, on the average of the whole of the experiments, but his own observations may have led him to see that some particular cane will prove suitable for some special condition, and he selects suitable canes accordingly.

The Imperial Department of Agriculture for the West Indies has been the means of raising several thousand seedlings every year, and it is hoped that the seedlings obtained by hybridization will lead to varieties of sugar cane, the pedigrees of which will be known, which will prove a commercial importance to producers of sugar.

It is fully realized that it is necessary to improve the crops by breeding continually for greater vigor and hardiness, and that definite qualities can be induced and intensified so long as systematic attention is directed solely toward this aim.

Over 20,000 plants (tops and portions of stems of seedling sugar canes) are annually exported from Barbados to other West India Islands, in all of which the area under seedling canes is gradually extending and it is hoped that a general improvement of the sugar industry will result from a continuation of the conjoined efforts of the experimentalists and members of the planting community.—[West Ind. Bull.]

OBSERVATIONS ON THE CULTIVATION OF THE SUGAR CANE.

BY LEON PELLET.

We have read with a considerable interest the articles published by Mr. Eckart (Director of Division of Agriculture and Chemistry of the Experiment Station of the Hawaiian Sugar Planters' Association) on the different varieties of canes in various countries.

The following remarks of his are of particular interest:

"Climate and soil are the paramount influences exerted on the sugar producing capacity of different varieties, and of these two conditions it is difficult at times to note which has the more determining effect on crop production."

We would like to make some observations on this subject.

Of these two paramount influences we propose first to examine that of the soil.

In every country where one or more Experiment Stations exist, the trials of the different varieties of canes are carried out so as to solve certain predetermined problems, among which we should note:

1. For the *ordinary conditions of cultivation* in the country, which is the best variety?

2. Which are the best physical and chemical conditions of the ground for the maximum crop, weight and sucrose content?

3. Which are the best physical and chemical methods to use so that the soils of the country shall give the maximum yield?

It is chiefly the second which is the most studied. It is the most scientific and demands a great number of tests, the leading idea of all these tests being as follows:

The experiment fields contain a soil of a definite physical and chemical composition (which may or may not be an average of the general soil of the country); from the results already obtained we decide to change the physical and chemical conditions so as to reap the maximum possible crop.

Therefore, the question is: In the actual state of our knowledge what would be an ideal composition of the soil?

This question has, it is true, been already settled in the different countries, and many articles been published on the subject, but we believe that it would be very useful and interesting to get up a review and to have the actual opinion of the main body of sugar cane workers.

Naturally the physical and chemical conditions will be different in consequence of the varying climatic conditions, but they will remain perfectly comparable among themselves.

In short, we would suggest that the agriculturist is the dominating factor of the influence of the soil.

The examination of the influence of the climate is more uncertain; the climatic conditions differ so enormously in the various countries where the sugar cane is grown. But we have as a guide in our comparisons two principal lines.

1. The amount of heat received by the cane.

This figure is obtained by adding up the mean day-temperatures during the whole period of vegetation

For example, if the mean day-temperature is 22° C. and if the vegetation lasts twelve months (360 days), the total amount of heat received will be 7,920° C.

Naturally this number differs greatly in each country. It will be 11,000 in the Hawaiian Islands and 6,000 in Spain or Egypt.

2. The changes in temperature during the day and night, and during the different seasons.

This factor is of the greatest importance, because in some countries the frost in winter is as bad for the cane as the extreme heat in summer. Certainly the ideal weather for this purpose is met with in the Hawaiian Islands. It is, however, easy to understand that the mean day-temperature might be the same in two countries and yet not give the same results.

If one takes into account these two factors, it is possible to state a proportionality between the heat received and the quantity of sugar produced, and in that case, all the results of the tests carried out in different countries will become much more capable of comparison.—International Sugar Journal.

PRELIMINARY NOTES ON ROOT DISEASE OF SUGAR-CANE IN HAWAII.

By L. Lewton-Brain.

(With 12 Original Illustrations in the Text.)

INTRODUCTION.

Root disease is very widely distributed in these islands; during the short time I have been here, specimens showing it have been received from several plantations on Oahu, Hawaii and Maui, and it would appear that the disease occurs, to a greater or less extent, in most of the sugar-producing districts of the group. It is by no means a new disease here; the characteristics symptoms of it have been observed for many years, although it is only recently that their real significance and importance has been generally realized.

A very similar root disease of cane is spread throughout the West Indies. In the island of Barbadoes alone, the loss in sugar and molasses caused by this disease in 1903 was estimated at nearly £100,000 ($480,000), the season of 1903 being extremely favorable to the spread of root disease. The West Indian root disease also occurs in Java, where it is known as the "donkelan ziekte."

In Hawaii, root disease is without doubt the most important of the fungoid diseases of the sugar-cane. It is largely owing to the fact that the Lahaina and Rose Bamboo varieties have proved, or have become, susceptible to root disease that it has become necessary to abandon them, in favor of the Yellow Caledonia variety, in many localities. So important and widespread is the disease that it has been considered advisable for me to prepare this preliminary bulletin, now, with the facts we have on hand, rather than wait until our investigations are complete, as these must necessarily be extended over a considerable period of time.

STRUCTURE AND FUNCTIONS OF SUGAR-CANE ROOT.

Before entering into an account of root disease itself, it may perhaps be advisable for me to describe, briefly, the structure of the normal root of the cane; for, unless the various tissues of the root are known and also the part each plays in the life of the cane, it will be impossible to understand how a parasitic fungus, which attacks one part or another, influences the growth and development of the cane plant as a whole.

A B.

FIG. 1. Two canes, from different stools, to show the effect of root disease on growth, from a photograph. These canes are of the same variety, and were taken from the same row, so that they were grown under identical conditions; they were between three and four months old. The cane on the right (B) is badly attacked by root disease, while that on the left (A) is only slightly attacked. (It was impossible to find a perfectly healthy cane for comparison.) See pages 10 and following.

ORIGIN OF ROOTS.

In the first place the sugar-cane has no main root from which other roots develop by branching. As in all plants of the grass family (*Gramineae*), the roots of the cane arise adventitiously from the stem. At every joint (or node) of the stem a large number of small, clear points can be seen; below each of these are dormant rootlets, each of which, if given the proper conditions, of moisture, darkness and warmth, will develop into a root. The root system, then, of the cane is fibrous, consisting of a large number of perfectly independent roots all arising from the stem. These roots do branch, but to a very limited extent; moreover, the life of the individual roots is also limited; after a time they die and their loss is made good by the development of new roots from the underground and lower portions of the stem.

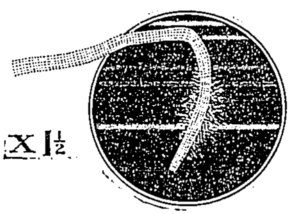

FIG. 2. Tip of sugar-cane root, showing root cap and position of root hairs. The circular black background in this figure is put in, in order to show up the delicate white root hairs. Magnified 1½ diameters.

Fig. 3 is a section through the apical part of this, going back as far as the root hairs, and it cut in the plane of the paper. Fig. 4 is cut through, across the long axis, in the region of the root hairs.

EXTERNAL FEATURES.

If some of the roots are allowed to develop in moist air, we get the appearance shown in Fig. 2. The root is for the most part pure white, but at the extreme tip it is of a dull yellowish or brownish colour; this brown part, as we shall see later, fits like a cap over the root tip and is, in fact, the root cap. In specimens exposed to light the root cap often assumes a pink or red color, as do sometimes other parts of the root, due to the development of a red pigment in the superficial cells.

Some millimetres behind the tip are to be seen a number of very fine delicate hairs, the root hairs. When the root is growing in the earth, the root hairs grow very close to the small soil particles; their walls become somewhat gelatinous and fuse very firmly on to the soil particles, so much so that in pulling a root out of the soil the root hairs are practically always broken and remain in the soil. The root hairs are thus in very close contact with the soil water, their walls are delicate and very permeable and it is through them that the water, with nitrates and other mineral salts in solution, passes from the soil into the plant. By watching carefully it is seen that, as the root grows forward, new root hairs are continually being developed in front, while those behind are as continually dying. So, as a root grows forward in the soil, its root hairs are continually coming in contact with fresh soil particles.

By careful measurements, the methods of which need not be described here, it is found that the growth in length of the root is confined to a very definite region. The region at the extreme tip does not elongate at all; elongation begins one or two millimetres behind the tip; it rises to a maximum a little further back, then sinks again until finally, in the region of the root hairs, there is no growth in length at all. The root hairs, then, as they develop, are not subjected to a continual dragging forward as they would be if they arose nearer the tip. As the growing region elongates, it pushes the root tip further and further into the soil.

STRUCTURE OF ROOT TIP.

These regions are brought out more clearly by examining a thin section, cut longitudinally through the middle of a root tip, under a low power of the microscope. Such a section, magnified 42 diameters, is shown in Fig. 3.

Starting at the tip, the first structure is the root cap (Fig. 3. *r.c.*). The outermost part of this is seen to be composed of loose, dead cells with brown walls. These cells are being constantly rubbed off, as the root pushes its way into the soil, and are as constantly being renewed from the living cells behind.

Covered over by the root cap is a mass of very delicate, thin-walled, closely packed cells forming the actual tip of the root (Fig. 3. *m.*). These cells are meristematic, that is to say, they are constantly in a state of active division. Fresh cells are thus continually being added, in front to the root cap and behind to the various tissues of the root. As these cells are cut off behind, they commence to elongate and various stages in elongation can be seen in Fig. 3. The formation and growth of these new cells behind the meristem, of course, forces this further and further into the soil. Hence we see the importance of the root cap in protecting the delicate cells of the root tip or meristem from coming into contact with the soil. The importance of the meristem itself can also be recognized; it is the only part of the root where new cells are formed, consequently if the meristem be injured or destroyed all growth must cease.

Turning now to the growing region behind the meristem, we find, besides the elongation of individual cells, another process taking place. This is the fusion of separate cells. The cross walls between two cells, standing directly one above the other, become dissolved, and the cavities of the cells become continuous. Whole rows of cells take part in this process until we get long tubes formed, which connect above with similar structures formed in the same manner. These tubes are seen only in the central part of the root and are known as vessels (Fig. 3. *v.*). Later on their living contents disappear and then their walls become thickened and chemically changed.

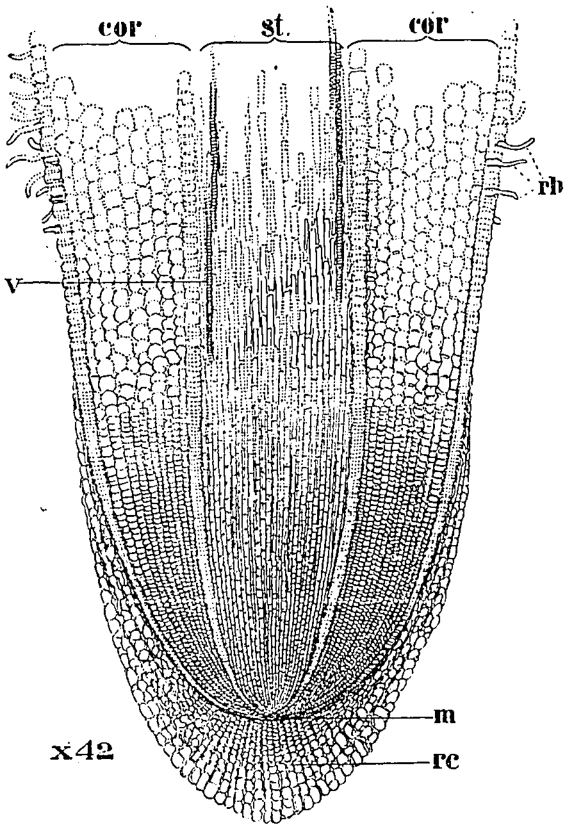

FIG. 3. Medium longitudinal section of tip of root, showing root-cap (r. c.), meristem (m.), piliferous layer with root hairs (r.h.), cortex (cor.), central cylinder (st.), with developing wood-vessels (v.). Magnified 42 diameters.

The root cap protects the meristem from injury, as the root pushes its way through the soil. The meristem is the region of cell division, and from it arise all the tissues of the root; note its thin-walled, small, closely packed cells, which are in an active state of division. The piliferous layer is the superficial covering layer of the root; a root hair is a simple outgrowth from one of its cells· the root hairs are the absorbing organs of the root. The woodvessels are the conducting elements of the plant. they carry the water absorbed by the root hairs up to the leaves; their walls become thickened, in various ways (spirally in the young ones shown), and woody.

Behind the growing region, we come to that part of the root where the cells, having attained their full length, begin to assume their permanent characters. The walls of some, notably of the vessels, thicken and change in various ways to fit them for their various functions. In this region, the root hairs are developed;

they arise as simple, tubular outgrowths from the outermost layer of cells (Fig. 3. *r.h.*), and their walls are seen to be extremely thin and delicate. New ones are constantly being formed nearer the tip as fresh cells of the outer layer assume their permanent shape, and form, and as constantly die away behind. After the root hairs are dead the outer layers of cells change their walls and become corky, so preventing the taking in of water in the region behind the root hairs, and protecting the inner tissues from injuries.

STRUCTURE AS SEEN IN TRANSVERSE SECTION.

After having seen the various tissues in longitudinal section and having traced their origin from the cells of the growing point, it will be well to examine their arrangement as seen in a section cut transversely through the root. Such a section, taken through the region of the root hairs, is figured, magnified 75 diameters, in Fig. 4. On the outside, we get again the special layer of cells, the piliferous layer, forming a kind of skin to the root, from which the root hairs are developed. The hairs (Fig. 4. *r.h.*) are seen again to be mere outgrowths from single cells. After the hairs have fulfilled their uses, the walls of these cells become corky, and the cells no longer function in absorbing water but only as a protective layer.

Within this outer layer, are noticed two regions very definitely marked off from each other; these are an outer cortex (Fig. 4. *cor.*), and the inner central cylinder (Fig. 4. *st.*). Comparing with Fig. 3, it is noticeable that these two regions are to be distinguished right down to the growing point and have their origin in separate parts of the meristem. The cells of the outer part are uniform, thin-walled, living and loosely arranged. The elements of the central cylinder are more varied and generally are smaller than those of the cortex. Standing out from the rest are certain thick-walled, woody elements (Fig. 4. *v.*), which occur in a large number of small groups (in the specimen figured nineteen), arranged in a ring near the outer part of the central cylinder. These thick-walled elements are the vessels, which as mentioned before, are really long pipes or tubes, formed by the fusion of several shorter elements. Within the ring of thick-walled vessels we see a smaller number of larger tubes (Fig. 4. *x.*), cut across. These are also vessels which have not yet thickened their walls or become woody. These groups of vessels are really strands cut across; every vessel joins on above and below to other vessels, so that we get a continuous system of pipes, starting near the root hairs, and running the whole length of the root up to its origin in the stem. Not only so, but these strands of vessels become continuous with similar strands in the stem and these in turn join on to the strands in the leaves which

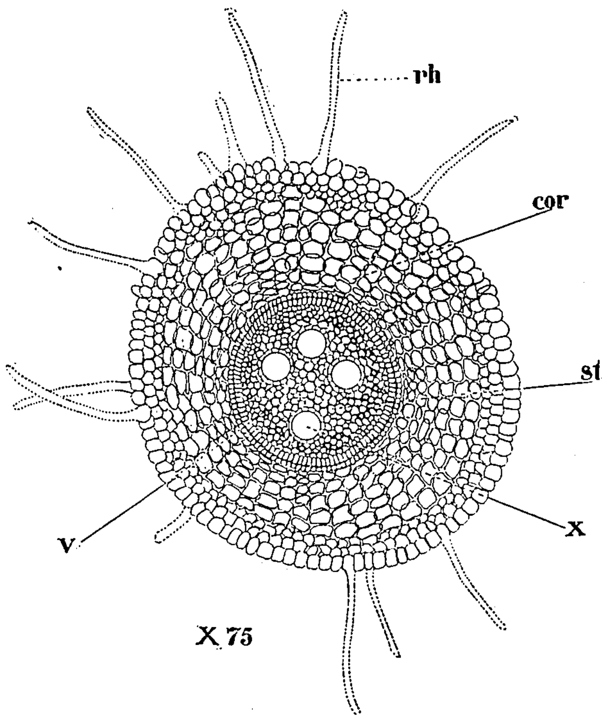

FIG. 4. Transverse section of root in region of root-hairs, showing piliferous layer with root-hairs (r. h.), cortex (cor.), central cylinder (st.) with first formed wood-vessels (v.) and developing larger vessels (x.). Magnified 75 diameters.

This section is taken across the part of the root corresponding to the top of Fig. 3. The two sections should be carefully compared, and the corresponding tissues in each made out. In this way a clear idea will be obtained of the relationships of the different parts of a young root.

are found in the ribs. Thus there is a continuous system of pipes, woody vessels, from the tips of the roots to those of the leaves. These wood vessels are the elements that conduct the water, with the contained food salts, from the roots to the leaves, where it is combined with carbon dioxide taken from the air and elaborated into sugar and other more complex organic substances.

FUNCTIONS OF THE ROOT.

The root system has two main functions; these are (1) the fixing and holding the plant firm in the soil, and (2) the taking in of water, with food salts in solution, from the soil and passing it up to the stem.

The sugar-cane has an enormous number of roots which spread in all directions into the soil. Each root has near its tip a large number of root hairs, each one of which practically fuses with the soil particles. It will easily be seen that the combined hold by the root hairs must be immense. Besides this there is the hold obtained by the mass of roots themselves in mixing and interweaving in the soil. It is this hold the roots have on the soil that prevents the plant being uprooted by the wind; generally the root system breaks before loosening its hold.

The taking in of water is also performed by means of the root hairs. These are in intimate contact with the water which collects around the soil particles, their walls are permeable and the water is absorbed. From the root hairs this water passes into the cells of the cortex and thence into the wood vessels of the central cylinder. It passes from one vessel to another up the root to the stem, and from the stem to the vessels of the leaves. From the vessels of the leaves it passes into the green cells. There the food salts and part of the water are worked up into organic substances; the excess water is given off in the form of vapor through the breathing pores of the leaves.

This is a brief summary of the course of the water current in the sugar-cane plant, and it will be seen that the whole process, so vitally important to the life of the plant, is entirely dependent upon the root hairs and upon new root hairs being formed to replace the old ones, as they lose their absorbing power.

SYMPTOMS OF ROOT DISEASE.

As I have already mentioned, the symptoms of root disease have long been known in these islands, though it is only comparatively recently that they have been recognized as symptoms of a definite disease. I have shown specimens of diseased canes to several plantation managers and nearly all of them are familiar with the appearances, and have been for some time. They are exceedingly characteristic, and once known, the recognition of root disease is easy.

It is noticeable here, as with the root disease in the West Indies, that the symptoms are nearly always much more marked with ratoons than with plant cane. Very often, where the plants have appeared to the ordinary observer to be quite healthy and have given a good crop, the ratoons have shown, after a few months' growth, marked indications of root disease and have been an entire failure.

The general appearance of a cane badly attacked by root disease is shown in Fig. 1. *b.*, while a cane of the same age and variety grown under the same conditions, but only slightly attacked by root disease, is shown side by side at Fig. 1. *a.*, for comparison. These canes were between 3 and 4 months old.

LEAVES.

The leaves being *the most conspicuous organ of the plant*, it is usually on them that the effects of the disease are first noticed. Instead of dark-green, broad. spreading leaves, these appear narrower and shorter and stand closer together. Normally the leaves remain green for a considerable time before they dry up, so that we get a dozen or more green leaves on a good plant at the same time. A plant affected with root disease shows a very different appearance; the leaves dry up prematurely, they turn yellow, first at the tips and margins, and the yellowing gradually spreads over the entire blade. Young leaves do not develop so rapidly as in the normal case and even those that are still green do not open out in a normal way, but remain wholly or partially rolled up, and stand erect. This rolling up of the leaves is a phenomenon met with in many grasses (including the sugar-cane) in dry weather; the breathing pores (stomata), through which water passes out of the leaves, are in this way protected from coming into free contact with the outer air. The rolling thus reduces the amount of water vapor passing out into the air, in connection with a diminished supply of water from the soil.

The whole appearance of the leaves, in fact, suggests lack of water. The older leaves, and first those parts of them remotest from the stem, dry up and die; young leaves, which give off water freely, develop slowly, while those that do develop roll up and stand upright to reduce their giving off of water.

The same symptoms are met with in canes suffering from drought, but then every cane in the drought-affected area will be affected and moreover the symptoms disappear as soon as the plants are supplied with water; when, on the other hand, the symptoms are due to root disease, in most cases only a limited area will be affected, and other neighboring canes, under the same conditions as regards water supply, will not show the same appearance. Moreover, when root disease is present, the symptoms are more permanent; they do not disappear, although they may be slightly less noticeable, with an increased water supply. Of course, on an irrigated plantation this question will not arise. On non-irrigated plantations, in districts where the water supply is capricious, root disease is often worse during a dry season and there is often confusion as to how much of the drying is due to drought and how much to root disease. In the West Indies this connexion between dry years and root disease is very marked; the same will probably be found to be the case here—certainly it is indicated by the fact that irrigated plantations have not suffered from root disease to the same extent that non-irrigated ones have.

LEAF-SHEATHS AND EYES.

One of the most characteristic symptoms of root disease is seen on examining the sheaths of the lower leaves. Normally, as these die, they dry up and fall away, or at any rate are easily stripped off, leaving the stem clean. In a diseased cane, on the contrary, they become matted very closely together round the stem, so that it requires some force to remove them. The sheaths are moist and rotten and possess a characteristic musty smell. This matting together extends for a foot or more from the level of the soil.

On examining these matted leaf-sheaths more closely, white thread-like strands may be seen running in and among and through them. These strands are similar to that shown on a young shoot in Fig. 5, and, magnified 42 diameters, in Fig. 7; as shown in Fig. 7 they sometimes broaden out, and sometimes instead of, or proceeding from, definite strands one finds broad, white felt-like plates. These strands and plates are really the mycelium, that is the vegetative part, of the fungus which causes root disease. It does not seem able to grow to any great distance above the ground, and only when sheltered by the matting of the leaf-sheaths which it brings about.

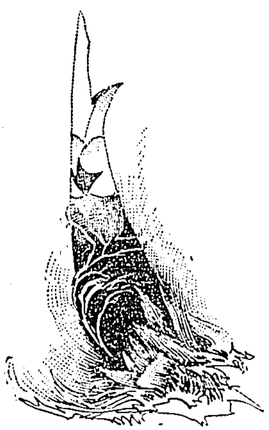

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FIG. 5. Lower bud of diseased sugar cane starting into growth. Note the white strands of fungus mycelium spreading out over the lower bud -sheaths. Natural size.

These strands are very similar to those found in the soil (Fig. 6), and are composed of the parallel-running hyphae shown in Fig. 8. The eye frequently grows away from the fungus, which, however, remains alive at the base of the young shoot, and begins to grow upward again as soon as the lower leaf-sheaths begin to lose their vitality.

Another feature of root disease, which, however, it shares with some other cane diseases, is the sprouting of the lower buds or eyes of the stalk. The fungus threads, at first, grow up with the young shoots as shown in Fig. 5. Generally the shoots grow away from the fungus; this, however, remains attached to the lower part and, as the lower sheaths on these shoots begin to die, starts growth again as on the main stalk.

ROOTS AND SOIL.

Stripping away the matted leaf-sheaths, another symptom of root disease is seen in the roots which have started developing from the nodes. In many cases hardly any of them are more than ¼ to ½ inch long, while others appear to have had their growth arrested as soon as it started. In other cases some roots may have developed some distance before their growth has been stopped. On a healthy cane, roots taken from a similar spot would be of all lengths up to several inches. The tips of these stunted roots look unhealthy, they are of a dull dark brown or black color and are flattened. Undeveloped roots often show as dark points in the rind of the cane at the joints.

Obviously the disease is showing here by preventing the growth of the roots, arresting their development, generally, at an early stage. Sometimes these roots are quite covered with the white felt of the mycelium of the root fungus.

Examining the soil about the base of a diseased cane one finds again the mycelium of the root fungus. This is easily seen on breaking off pieces of the soil, and takes the form of white thread-like strands as shown in Fig. 6, quite similar to those met with between the leaf-sheaths. The strands may be seen ramifying and branching, passing sometimes from one dead root to another, sometimes in the soil itself; together they form a branching network all around and among the cane roots.

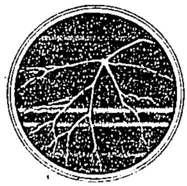
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FIG. 6. Infected soil (represented by the black background) with white strands of fungus mycelium, showing how the fungus spreads in the soil. Natural size. These strands, which occur in great numbers about the bases of diseased canes, are one of the clearest indications of root disease. On breaking the soil from such a locality across, the strands are nearly always plainly visible.

EFFECT ON GROWTH.

A cane stool attacked by root disease usually begins to show its effects when growth has been going on a few months and when the stalk is beginning to form. Later on, a diseased stool presents a very poor appearance, there are only a few stalks, and these are shorter and thinner and drier than in a normal cane. The stool in fact looks starved. Apart from this, the stems show no diseased phenomena.

Another feature of diseased stools is the slight hold they have on the soil. In bad cases a slight pull with one hand is sufficient to uproot a stool; even in less marked cases, the attachment of the plant to the soil is much feebler than that of a healthy cane.

The starved appearance of the stool suggests that the roots are not fulfilling one of their main functions, that of supplying water and food salts. The ease with which the plant is pulled up shows they are not fulfilling the other, that of anchoring the plant in the soil.

In these islands root disease sometimes shows itself very early in growth. I have seen young shoots, not a foot high, turning yellow, and exhibiting all the signs of root disease. These on examination have been found to be attacked by root fungus. They were, later on, killed off by the disease. The same effect has been noted with the donkelan disease of Java.

EFFECT ON GERMINATION.

More than this, there is evidence to show that the root fungus attacks germinating cuttings and prevents the development of the eyes. Mr. C. F. Eckart, Director of the Division of Agriculture and Chemistry, carried out some experiments in 1904 which tend to show this. The following is his account of the experiments:

"In April, 1904, a stool of Lahaina cane was received from the Waiakea Mill Co. which was badly checked in growth and from which but few roots developed. This was submitted to Mr. R. C. L. Perkins for examination shortly prior to his departure for Australia. Mr. Perkins stated that the roots of the cane were infested with parasitic fungus. It was then determined to carry out the following experiment:

"(1) Two tubs containing 150 lbs. each of Experiment Station soil received 4 lbs. of soil from around the diseased cane clump. Lahaina cane cuttings, 5 in number, each bearing 3 eyes, were planted, i. e., 30 eyes in all, for the two tubs.

"(2) Two tubs were treated the same as in (1) except that the cane cuttings were soaked for 12 hours in Bordeaux mixture.

"(3) Two tubs were filled with 150 lbs. Station soil and untreated Lahaina cuttings were planted as in No. 1.

"The planting in these tests took place April 23, 1904. On July 27, the cane was cut and weighed. The following data were obtained:

"(1) 10 eyes germinated. The largest cane measured from base of stalk to tip of highest leaf 6 feet. The weight of green matter formed was 188 grams; of root, 22 grams.

"(2) 17 eyes germinated. The largest cane measured 5 feet 6 inches. The weight of green matter formed was 399 grams; of roots, 20 grams.

"(3) 13 eyes germinated. The largest cane measured 7 feet 1½ inches. The weight of green matter formed was 406 grams; of roots, 37 grams.

"In explanation of the poor germination of eyes, even in the case where uninoculated soil was used, it is necessary to state that all of the tubs were placed on a shady verandah and consequently received the direct rays of the sun only during a small portion of the day."

Speaking at the Planters' meeting in 1904, Mr. Eckart thus sums up his conclusions:

"A short time ago we got some soil from down in the Hilo district where root disease is prevalent and where it is necessary to replace the Lahaina with more healthy and thrifty varieties. We inoculated, in tubs, some of the station soil with a little of the soil from Waiakea that was obtained from around Mr. Kennedy's plantation. Wherever we inoculated the station soil with the soil from Waiakea, there was a difference in the germination of the cane cuttings from where we had not inoculated the soil. That would indicate that our disease is different from the West Indian disease."

In the West Indies *Marasmius sacchari*, the root fungus of those islands, has never been proved to have any effect on germination. In Java, however, the same fungus, *Marasmius sacchari*, is known to destroy cane cuttings in the nursery beds, in which the canes are placed before planting out, besides attacking mature canes. So the fact that the Hawaiian root fungus prevents germination is no proof of its being different from the root fungus of Java and the West Indies. The following translation from Wakker and Went's book on sugar-cane diseases in Java shows this point clearly:

"It is peculiar that this disease appears in two different ways, but at the same time of the year; I deem it desirable first to describe the symptoms in both cases separately and will then try to explain the supposed relation.

"I would like to add now that the symptoms present themselves in the first place in the nurseries, which are not too young, and in the second place in mature fields during or immediately before harvesting. The latter symptoms are the most serious.

"The following symptoms are observed whenever nurseries are affected:

"First the number of sprouting buds is always much smaller than otherwise. As the non-sprouting of buds can also be caused by a number of other circumstances, for instance, age, damage by insects, etc., it cannot be classed as a characteristic symptom of the disease.

"Second, and this is much more typical, we see that the already sprouted buds begin to show a weak appearance just by the time of transplanting, that is nearly three weeks after the nurseries were started.

"The most conspicuous feature is, that first the younger leaves, sometimes also the older leaves, start to die from the top and soon dry up, assuming a pale straw-like color, without spots or an edge of a strikingly different color.

"Such buds do not die but lead a poor existence and can even be transplanted.

"Between the extremes mentioned many intermediate forms are found, as might be expected. Especially I observed, here and there, buds of which only the bud-sheaths had grown, without leaves having formed.

"Generally speaking, the superficially observable symptoms resemble somewhat the damage done by white ants. Upon investigation of the parts under the surface it appears that if it is really root disease, the easily recognized inroads of above mentioned insects are not to be seen.

"Instead of cuttings, of which not much is left besides the shell with here and there a piece of the joint, they are apparently normal, and only a single bundle of mycelial threads, snow-

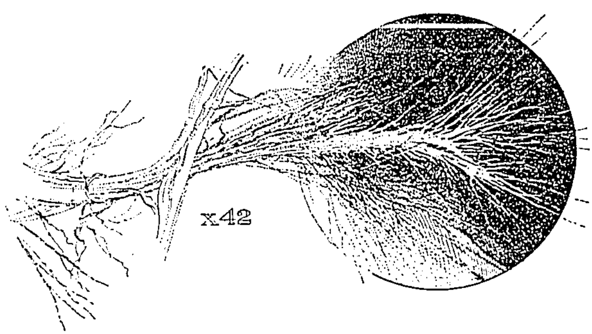

FIG. 7. One of the strands shown in Fig. 5, magnified 42 diameters, to show the method of branching and spreading out of the strands and indicating the arrangement of the hyphae. (The black back-ground toward the top of the illustration is necessary in order to show up the fine white strands of the myselium and its mode of branching.)

white and glossy, like silk, extending over the seed, branching off here and there and losing itself in the soil, arouses suspicion.

"If one cuts the seed lengthwise, it often presents a hollow space inside, filled with the threads mentioned or shows red spots on the joints. This color is not essential, I never did see red spots like those of 'Rood Snot' or vascular bundles partly colored red in the joints as in the case of 'Sereh.'

"The root formation is always more or less defective and the ends of the cuttings are rotten.

"As shown in the above, the charactertistics of the disease are not very prominent and I consider this the cause why the disease, although it can do much damage, was discovered only very recently."

Of course, Mr. Eckart's experiments though extremely suggestive, are not perfectly conclusive. The Waiakea soil used for inoculation *may* have contained the spores of other fungi, notably of the pine-apple disease of cuttings, and these *may* have been the cause of the poor germination in the inoculated soil. In the absence of a plant pathologist it does not appear that any post-mortem examination of the cuttings was made. It is proposed to repeat the experiment later, using sterilized soil and pure cultures of the root fungus.

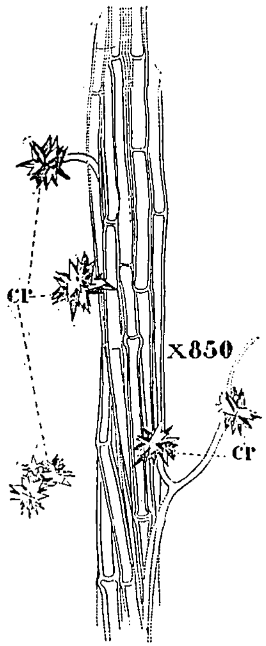

FIG. 8. Some of the fungus mycelium from a strand similar to that shown in Figs. 5 and 7. Note the branched, septate hyphae, their (for the most part) parallel arrangement, and the interweaving. The septa are simple cross walls and no clamp connexions are shown. Notice also the star-shaped clusters of crystals of calcium oxalate (cr.) borne on hyphae which stand away from the general course of the strand. Besides these clusters, single crystals are sometimes found in great numbers studding the walls of the ordinary hyphae. Crystals of calcium oxalate are common in fungi and are probably a by-product of metabolism. Magnified 850 diameters.

MICROSCOPIC EXAMINATION OF THE ROOT FUNGUS.

If one of the white strands of the root fungus, either from the soil or from the leaf-sheaths, be examined under a microscope we get the appearance shown in Figs. 7 and 8. The strand is seen to be composed of a number of very fine threads; these are the hyphae of the fungus, which together form the mycelium. In the strands the hyphae are seen to be running mostly in the same direction, along the long axis of the thread, but rather irregularly and interbranching and interweaving enough to make the strand a compact whole.

When the mycelium spreads out into the form of a plate, it is accomplished by the hyphae ceasing to run parallel to one another but branching and interweaving in all directions.

The hyphae vary somewhat in size, those shown in figures 8 and 11, for instance, measure about 1-1,000 millimetre (1-25,000 of an inch) in diameter. Seen under a high power, the hyphae are divided by cross walls (septa) into segments, as are those of all the higher fungi. Most of the septa are of the ordinary form, being simple cross walls (Figs. 8 and 11), but occasionally one meets with a joint as shown in Fig. 9. This is known as a clamp connexion; it is formed by the growing out of a process, just on one side of a septum, which curves round to the wall on the other side of the septum and fuses there; the separating walls break down and a side connexion is formed between the two adjoining segments of the hyphae. These clamp connexions are mentioned because, as will be seen later, they are of some systematic importance. The highest group of fungi are the Basidiomycetes, characterized by the production of toad-stools; to this group belongs the root fungus of the West Indies and Java. Clamp connexions are to be found in the hyphae of nearly all Basidiomycetes and hardly ever outside this group.

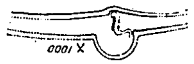

FIG. 9. Part of a hyphae of the root fungus from a strand similar to that shown in Fig. 7. Note the structure of a clamp connexion and compare with the structure of ordinary joints, as shown in Fig. 8. Magnified 1000 diameters.

Clamp connexions are not easily found in the mycelium of root fungus; that they do occur is additional proof that the fungus is a Basidiomycete.

A characteristic feature of the hyphae of the root fungus is the presence in their walls of crystals of calcium oxalate (Fig. 8, *cr.*).

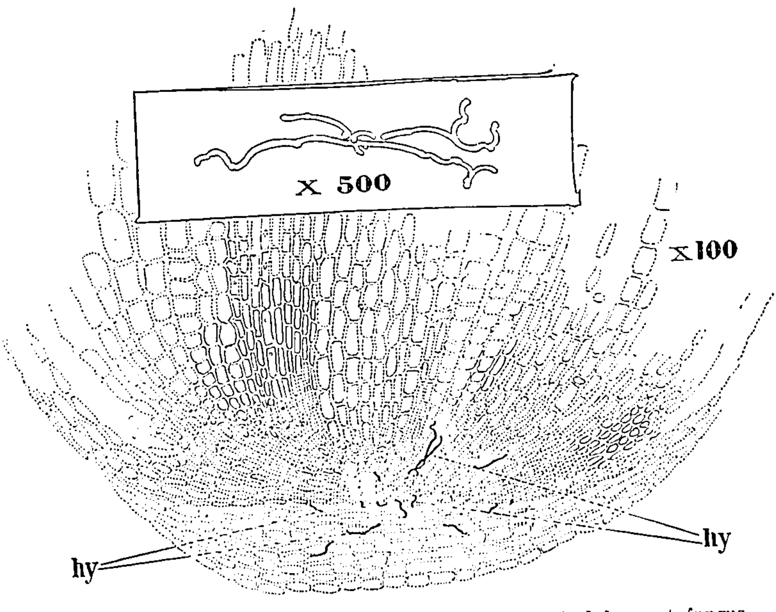

FIG. 10. Longitudinal section of root tip attacked by root fungus. Note the small fungus hyphae (hy.) in the tissues of the root cap and passing from there into the meristem. Compare this section with that shown in Fig. 3; notice the smaller, flattened-out root cap and the less active meristem cells; later on the tissues of the root cap and meristem are completely destroyed. Branches commonly arise quite close to the diseased root tip; these in turn are attacked by the fungus. Magnified 100 diameters.

FIG. 11. A few of the fungus hyphae from Fig. 10, magnified 500 diameters. The hyphae are septate, the septa being of the usual type. Compare with Fig. 8.

These hyphae branch and wind in all directions in the diseased tissues; many of them are cut straight across, and only the cut ends are seen in section; owing to the small size of the hyphae these ends could not be shown in Fig. 10.

The crystals are usually produced as shown, in a star-shaped manner, on the swollen tips of short hyphae. Sometimes, in addition, large numbers of single crystals are found embedded in the walls of the ordinary hyphae.

MICROSCOPIC EXAMINATION OF DISEASED ROOTS.

Longitudinal sections of diseased roots were prepared and examined microscopically; the roots selected were those described above as stunted in growth and with a discolored tip. A section of one of these, from Lahaina cane, is shown in Fig. 10, magnified 100 diameters. It may be mentioned that the section figured here was taken from a root growing from a point 9 or 10 inches above the soil.

At once it is seen that the tip differs from that of a normal root (compare Figs. 3 and 10). The root cap is evidently much reduced and looks unhealthy, the cells are flatter and show no signs of being replenished from the growing point.

The growing point itself also shows evidences of disease, it also is flattened out and does not appear to be actively forming new cells. This is especially noticeable in preparations stained to show the cell contents. In a normal growing point, the cells are full of living matter, which is found actively dividing and giving rise to new cells. In a diseased tip, the living matter is less in amount and evidently active division is ceasing.

Careful examination with a high magnification shows the cause of the trouble. A number of very delicate fungus hyphae (Fig. 10. *hy.*) are found penetrating in and among the dead and dying cells. The hyphae, as seen by a comparison of Figures 8 and 11, are similar, in their general characteristics, to those of the white mycelium outside. They appear to penetrate the root cap first and to pass from this into the actively dividing cells of the growing point. In both places they branch in all directions growing into both living and dead cells. They absorb the food supply of the cells and when these are killed, live on their dead remains; in this way all the living cells of the growing point are soon killed and the dead tissues invaded in all directions by the fungus mycelium. It is now easily understood why the root tips seen from the outside appear discolored.

The root tip shown in Figure 10 is only in an early stage of this disease; later on, as described above, the root cap and growing point are entirely destroyed and flattened out and the fungus then spreads to the young cells of the cortex; it does not, however, while the root is alive, seem to penetrate far into the central cylinder.

Often the root seems to make an effort to overcome the parasite by branching quite close up to the dying growing point.

It produces, in fact, another growing point to replace that destroyed. Root branches arise from the central cylinder and have to push their way through the cortex. With root disease, usually before the branch has emerged, its growing point is attacked and destroyed as was that of the parent root.

Later, after the root has been killed, the fungus spreads to all parts of the root and promotes its decay. In this it is aided by other fungi and by bacteria which are present in the soil. But for all practical purposes, the direct damage done by the root fungus is confined to one spot, the growing point of the root.

(To be continued.)

TAX ON SUGAR PLANTATIONS IN CUBA.

Consul-General Steinhart, of Habana, in reply to inquiries regarding rate of taxation on sugar estates in Cuba, writes as follows:

The rate of taxation upon plantations is 3 per cent., calculated upon the number of caballerias (33 1-3 acres) of cane under cultivation. The production is calculated, more or less, in arrobas (25.4375 pounds) of cane, and estimating that 100 arrobas of cane produce 5 arrobas of sugar, the value of the production is taken at the current prices of sugar, i. e., average market price.

This is effected upon the sworn declaration of the owner, verified by the municipal board. If found to be correct the board accepts it, and if not, rectifies it. If the owner does not agree with the rectification he has the right of appeal to the junta provincial. The rate of taxation is the same all over the island. Plantations pay only upon the caballerias of cane that the owner cultivates. The "colonias" (a plantation without a sugar mill) pay only at the rate of 6 per cent. in the manner before described. Plantations pay nothing for the industry of sugar making, nor under any other heading, further than the tax of 8 per cent. upon the production of cane. The municipality collects the tax, the State collects none.

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	Paauilo
Kukaiau Plantation	x	J. M. Horner	Kukaiau
Kukaiau Mill Co.	*x	E. Madden	Paauilo
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	‡‡	W. L. Vredenburg.	S. Kohala
Niulii Sugar Mill and Plantation	*x	Robt Hall,	Kohala
Puakea Plantation	*x	H. R. Bryant	Kohala
KAUAI.			
Kilauea Sugar Plantation Co.	**	A. Moore	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	(5)
**	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**	F. A. Schaefer & Co.	(2)
x*x	H. Waterhouse Trust Co.	(2)
‡‡	Hind, Rolph & Co.	(2)
xx	Bishop & Co.	(1)