

IX

SPECIAL AGRICULTURE AND INDUSTRIES

SUGAR CANE: ITS CULTIVATION AND VARIETIES—MOSAIC DISEASE—TWO DESTRUCTIVE SUGAR-CANE DISEASES—CENTRAL SUGAR MILLS—SUGAR MANUFACTURE—ASSOCIATION OF SUGAR PRODUCERS. TOBACCO: CULTIVATION OF TOBACCO—CIGAR AND CIGARETTE MANUFACTURE—ASSOCIATION OF TOBACCO GROWERS. COFFEE: CULTIVATION OF COFFEE—PICKING, PREPARATION AND QUALITY—ASSOCIATION OF COFFEE PRODUCERS. FRUITS: CITRUS FRUITS—PINEAPPLE—AVOCADO—MINOR CROPS—ORNAMENTAL PLANTS—LIVESTOCK INDUSTRY—NEW INDUSTRIES.

Sugar Cane: Its Cultivation and Varieties

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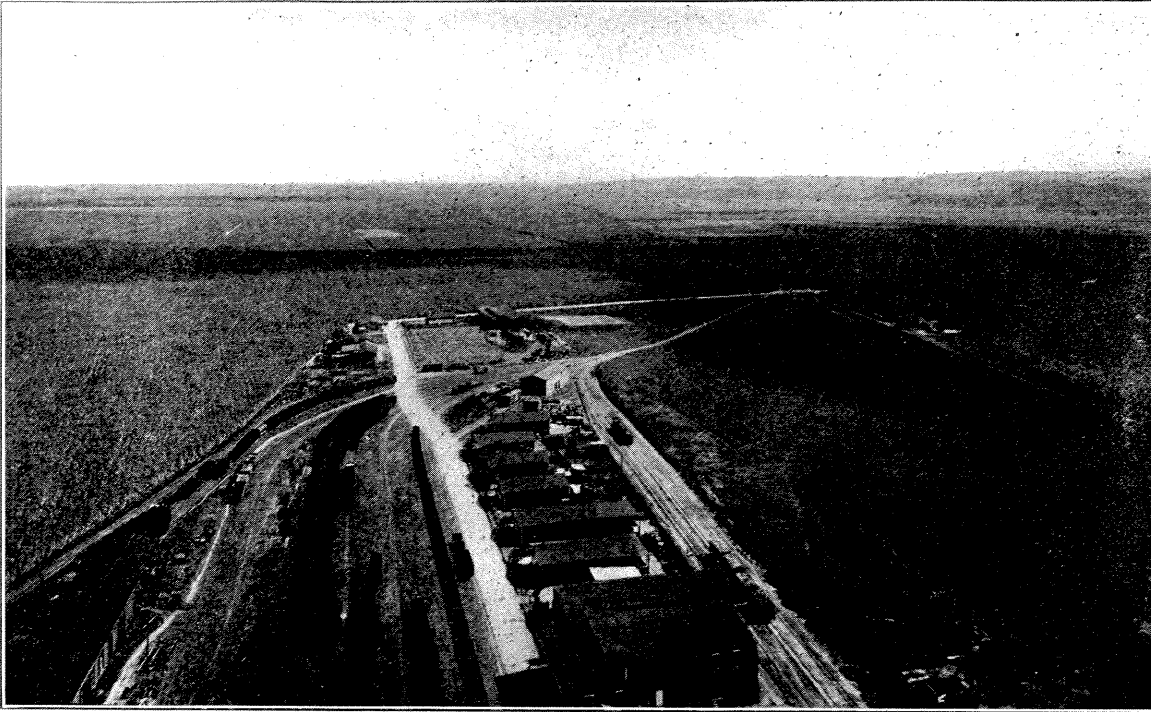
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Variety and Extension of Land Under Cultivation: Sugar long has been, and probably always will be, the chief agricultural industry of Porto Rico. Sugar cane is mostly planted on the comparatively level lands near the coast, though its culture also extends into certain of the hill lands of the interior and to the broader interior valleys, wherever transportation facilities are adequate. Cane can be grown successfully on a great variety of soils, ranging from light sandy loams to the stiffest clays. It thrives best, however, on a rather heavy loam, provided it has been well pulverized by deep and thorough preparation, and is kept loose and well aerated by frequent tillage. The greater part of the really available cane lands are already in cultivation, so we cannot look for any great increase in the present acreage, which is estimated to about 200,000 acres. This, however, by no means implies that Porto Rico has reached the limit in sugar production. It would be easily possible to double the present average yields by better cultivation, and the more careful selection of varieties best suited to each local condition.

Introduction of the Uba Cane: The introduction of Uba cane, too, is a factor that may result in considerably extending the area now in cane culture, since it thrives and yields well

on many classes of lands where the ordinary kinds cannot be profitably planted. This remarkable variety has only recently been introduced into Porto Rico, although for many years it has been the only kind planted in Natal and other parts of South Africa. A few seeds were first brought in by mail from the Argentine by the Mayaguez Experiment Station, and it was found to be absolutely immune to the mosaic disease, or "matizado," that has been devastating the cane fields of Porto Rico, particularly in the western districts; ten tons of this seed were imported from the Argentine by the United States Department of Agriculture as an aid in combating the disease. Many thousands of acres have been planted for this purpose, but aside from its disease resistance it seems likely, as just noted, that it will considerably increase the total area planted to cane on account of its ability to grow and yield well on the poorer classes of soils. On rich lands it is usually too low in sucrose to be fully desirable.

Classes of Cane Soils: The principal cane soils of Porto Rico may be roughly divided into the following six classes: 1st. The Maritime Soils: these include what until comparatively recent years were the bottom of the shallow salt water bays and lagoons. Later these became mangrove swamps and salt



CAÑAVERALES DE LA CENTRAL CAMBALACHE.—CENTRAL CAMBALACHE SHOWING SUGAR CANE FIELD.

marshes and now, by the continued accumulation of debris of all kinds, principally rotted vegetation, they have become high enough to permit of cultivation. The lower, more marshy parts, are locally known as "poyals." These show permanent water in the drainage ditches, and are always so moist as to require little or no irrigation. The somewhat higher levels are known as "semi poyals" and uplands. These maritime soils are found in considerable areas along both coasts, and constitute an important factor in cane production. These soils are all stiff, and retentive of moisture. They are difficult to work, and on all of them drainage is most important. Rich in plant food, they yield fine crops when properly handled, but on account of their compact nature they require more tillage than is usually given, and as the vegetable matter they contain becomes exhausted by continued cropping, cane suffers greatly from root disease. Some areas of these lands still contain too much salt for cane cultivation.

2nd. The Alluvial Soils: These have been built up along streams by deposits of silt, sand and gravel. They form the bottom lands along

all streams, and in the South Coast especially they have spread out to form an extensive, nearly level flood plain, which constitutes the most valuable sugar cane area on the Island. These deposits overlap and merge into the maritime soils, so that it is sometimes difficult to draw a sharp line between them. They are, however, more friable to cultivate, require less surface drainage, and as a rule they remain productive longer under present methods of handling. In some spots heavy deposits of gravel reduce their value.

3rd. The Red Coral-limestone soils: These are found in an area of considerable width, occupying the lower levels among the sharp limestone hills along the North Coast, from the Toa River west to Rincón. Their broadest extension occurs in the Isabela district. These soils are red in color, friable in texture, and extend down unchanged, without subsoil, to the coral rock floor on which they have been deposited. Owing to their friable structure, and the cavernous limestone on which they lie, these soils are perfectly underdrained, no surface ditching of any kind being required. With abundant rainfall they

are quite productive when new, but become exhausted rather quickly, and suffer badly in seasons of drought. They respond quickly to fertilizers, and especially to green manuring. They are equivalent to the Cuban "red lands," though usually a little lighter in consistency.

4th. Calcareous soils with a white subsoil: There are only comparatively small areas of this type of soil in Porto Rico, mostly in the southwestern districts. It occurs extensively in Cuba, especially in the Central Provinces, and is there second in importance only to the "Red lands" in cane production. The top soil is an easily-worked black loam, usually quite shallow, and the subsoil is a nearly pure carbonate of lime, but soft enough to be easily entered by the plow. They are very similar to the "rotten limestone" prairies of Alabama and Mississippi. These lands are easily cultivated, require little or no ditching, and usually yield good crops, but they need frequent green manuring to keep the shallow soil well supplied with humus.

5th. The Red Shale Clays: These constitute a very extensive soil area extending over the foothills and the northern flanks of the main central range all the way from Fajardo to Mayagüez. These soils are reddish or yellowish in color, stiff and difficult to work, and the lower lying portions need careful ditching. They are usually deficient in vegetable matter, and as ordinarily farmed they yield poor crops. No lands in Porto Rico will, however, respond more generously to better agricultural methods. They need applications of ground limestone, green manuring, a fertilizer rich in phosphates and better preparation and tillage. With this treatment they become as productive as any land on the island. By the better farming of these lands the sugar production could be very considerably increased.

6th. The Black Hill Lands: At various places in the foot hills, particularly in the Eastern districts, there are limited areas of a rich black soil derived from some of the older igneous rocks. This is a particularly good cane soil, and is giving much better crops under present methods than the red soils mentioned above, but their area is too limited to make them of more than local importance.

Besides these six main types, cane is occasionally planted in a great variety of other soils, and but for the difficulties of transportation, it could be grown successfully on most of the heavy coffee soils of the interior.

Need of Better Agricultural Methods: The necessity for better tillage and in general for the adoption of modern agricultural methods in the cane fields is only just beginning to be realized in Porto Rico. The manufacturing side of the sugar industry has been revolutionized in the past twenty-five years. The best mills are now as well equipped and as efficiently run as those in any other sugar producing regions. But sugar cane agriculture, aside from the use of mechanical power in plowing, still largely follows the methods in use a hundred years ago.

When it is once fully realized that sugar is all made in the field, not in the factory, when the same attention is given by those in authority to the solving of agricultural problems, that is now given to mechanical ones, then it will be easily possible to double the sugar production of Porto Rico. Soil and climatic conditions here are not so different from those in Hawaii as to account for the tremendous difference in sugar yields. There is nothing in our natural conditions to prevent our best irrigated lands closely approximating the heavy yields now secured by the better-class Hawaiian plantations.

Principal Varieties Grown: One of the most important factors in improving cane yields is to carefully study the question of varieties, and to select for each field the kind most likely to succeed under local conditions. Up to the beginning of the last century, only one kind of cane was grown in Porto Rico, or in any other of the West Indies. This was a slender, feeble-growing kind from India, that came to Spain during the Crusades, and was brought from there to these islands soon after their discovery. It came to be known as the Creole cane, and though it served for the early establishment of the industry, its development on the present scale would have been impossible on account of the low yields. If planting should have been confined to this variety. It long since passed out of general

cultivation, and is now almost extinct, only an occasional stool being found planted in door yards because it is so soft a cane that it is a favorite for chewing.

The Otaheiti or Caña Blanca was introduced into the West Indies toward the end of the eighteenth century. It soon reached Porto Rico, and quickly supplanted the Creole, since it yielded from a third to a half more sugar per acre. It is a large, handsome green cane, yellow at full maturity, and is particularly adapted to new lands, where the forest has been recently cut. Its introduction served as a great stimulus to the sugar industry, and really made its present development possible. Notwithstanding its rapid, vigorous growth, when all the conditions are favorable, this cane has a feeble root system, and as lands have become old and compact, from the exhaustion of vegetable matter, it has failed in one cane-growing country after another, with the symptoms that have come to be known as "root disease." Its planting is only continued in a few special localities, where soil conditions are still favorable. It persisted in general cultivation longer in Porto Rico than in most cane-growing countries, but is only now found in parts of the central hill districts, and in certain restricted localities on the Southern Coast. Besides its pronounced tendency to suffer from root disease, it is also very susceptible to mosaic, "matizado," and to gum disease. The outbreak of this last very serious trouble in Porto Rico is so far almost exclusively confined to this variety. This indicates the necessity for immediately abandoning its planting. In fact, the situation is so critical as to amply justify a legal enactment to prohibit its planting.

The Cheribon Canes: The early importation of Otaheiti cane seems to have been somewhat mixed with other kinds. Among these were occasional stalks of a purple cane, a striped cane, and a whitish cane with a pink blush. In different countries these have been known under various names as "Louisiana Purple," "Louisiana Ribbon" and "Crystallina or White Transparent." They are all simply color variants of one old kind of cane that is properly called Cheribon, from the district in

Java, where it originated, or at least, where it had long been grown.

These canes attracted no attention in Porto Rico until about 1873, when an epidemic appeared in the Mayaguez district, which attacked the Otaheiti cane and forced the abandonment of its cultivation throughout the western portion of the island. It was soon observed that the scattered stools of the Cheribon cane were not attacked by the disease, and they began to be selected out and planted in the diseased districts. For some unknown reason, the purple form (*morada*) never attracted much attention in Porto Rico, but the stripped form (*rayada*) and the *Crystallina* soon become the standard varieties for the island, the former being more planted on the North Coast, and the latter on the South Coast. To this day these canes are probably producing three-fourths of the sugar of the island.

On good land, these canes are very satisfactory commercial kinds, yielding good tonnage, ratooning well, and giving richer juices than any other kinds in general cultivation here. Unfortunately, as land becomes more and more exhausted from continued cane planting, these fine kinds are beginning to fail. While much more resistant than Otaheiti, they, too, are in many places showing the symptoms of root disease, especially on the older maritime lands. They are also susceptible to mosaic and to gum disease, though in a less degree than the Otaheiti.

The gradual failing of the Cheribon canes in so many districts is making it necessary either to improve cultural methods, or to look for still more resistant kinds; with better tillage and frequent green manuring it seems certain that these kinds of cane can be continued in profitable cultivation for many years to come, at least in the better classes of cane lands.

The Cavangerie. The epidemic of 1873 attracted much attention to the question of cane varieties, and caused the importation of twenty or more kinds, mostly from the French West Indies. A number of these are still to be found in the island, and some of them have

considerable value and interest, but only one of them has come to be widely planted, the Red cane, or French cane, properly known as Cavangerie.

This is a handsome claret red cane with a

bon canes begin to fail from root disease. This cane thrives in wet compact soils since it is very resistant to the ordinary forms of root disease, but it does not endure drought well. In suitable locations it gives heavy ton-



CAÑA DE VARIOS CORTES, VIEQUES.—SECOND GROWTH CANE.

bronze stripe. Color forms without the stripe also occur. It is hardy and vigorous, yielding good tonnage, especially on poor dry lands where other kinds fail. It is, however, very late in maturing, and as usually cut contains very little sugar. It has come to be extensively planted in the red shale lands of the interior and also on the red coral lands of the North Coast. It is very hardy as to root disease, but it is one of the most susceptible kinds on the island to the mosaic. It is not immune to gum disease but resists it so well that it came to be the standard kind in Brazil, when that country was overrun by this trouble some years ago. While it unquestionably has its good points, especially for poor dry soils, it seems certain that equally hardy kinds can be found that will make much better yields of sugar.

Yellow Caledonia: This variety which fills such an important place in Hawaii has come to be extensively planted in Porto Rico especially in the exhausted soils where the Cheri-

nage but it is very late in maturing and as usually cut in Porto Rico it yields very poor juices. As successfully handled in Hawaii it is seldom cut under 20 months of growth. It is susceptible to mosaic, but it is very resistant to gum disease. It is a useful cane when properly managed but it is not well adapted to present Porto Rican cropping methods.

Introduction and Production of New Seedlings. The Uba Cane: During the past twenty years a considerable number of the seedling canes produced in Barbados and Demerara have been introduced into Porto Rico, and a very large number of seedlings have been grown locally by the Experiment Stations, and by the Centrals Guánica and Fajardo. Some of these are very promising.

The Uba cane already referred to, from its vigor and hardiness and its complete immunity to all the serious cane diseases occurring in Porto Rico, is being very rapidly extended especially in the western districts that have

suffered so seriously from the mosaic outbreak.

It is certainly a remarkable variety and its introduction is bound to exert a profound influence on the future of the sugar industry in Porto Rico. To what extent, however, it will continue to displace the other kinds, once the present outbreak of disease is overcome, still remains an open question largely because of the difficulty of properly ripening the Uba on moist rich lands. The quality of its juices is exceedingly variable. On well drained uplands it is sometimes as good as the best, but the average from the low lands has been very poor. In such locations nitrogen fertilizers should be avoided, and on irrigated lands water should be withdrawn very early.

Selection of Varieties to Meet Soil and Climatic Conditions: Among the great number of varieties of cane now to be found in Porto Rico there are comparatively few that are really well adapted to planting on all the different types of soil. The Cheribon cane, Rayada and Crystalina, are really remarkable in this respect, since they thrive on all of the soil types that have been mentioned, so long as general fertility and a fair amount of humus is maintained. Their continued general planting is urged on all lands so long as they still yield a satisfactory tonnage. Their planting should not be abandoned until the effect of the green manuring with cowpeas or other legumes, and of much more frequent tillage has been fully tested. They are particularly suggested for the alluvial lands, the better maritime soils and the black hill lands.

Other good varieties that are equally rich in sucrose and that seem to be well adapted to a wide range of soil conditions are D 109 and B. H. 10 (12). These are all medium season kinds not reaching their best development in sugar before February or March. For

this reason no plantation should depend exclusively on any one variety no matter how satisfactory its growth. At least 20% of the acreage should be in some very early maturing cane to cut at the beginning of the crop. This point has not been sufficiently considered in Porto Rico and early maturing kinds have not been thoroughly tested. Among those that seem to be most promising are D 74, B 1030, St. C. 12 (4), GC 76, P. R. 333, and P. R. 492. Any one of these may be expected to give a tonnage about equal to Rayada and Crystalina and to show from 2% to 3% more sucrose during December.

Varieties Best Adapted to Classes of Soils Mentioned: Taking up the soil areas in order, the following varieties may be recommended for planting on each, always remembering that such recommendations must be modified by local experience.

Maritime Soils: Cheribon canes (best lands only), D 433 (especially in Eastern districts), D 117 (Western districts), B 6292, B 208 (best lands only).

Alluvial Soils: Cheribon canes, B 208, B. H. 10 (12), P., R. 433, (any good variety will succeed well here).

Red Coral Soils: D 109, B 3405, St. C. 12 (4), Uba, B. H. 10 (12).

Calcareous Soils with White Subsoil: B 3412, B. H. 10 (12), St. C. 12 (4), Uba.

Red Shale Soils: B 3405, B 3696, D 109, D 117, B. H. 10 (12), St. C. 12 (4), Uba.

Black Hill Soils: Cheribon canes, B 208, (any good variety).

Editorial Note: The letters and numbers used above are the names of new canes obtained by cross pollination and at the same time indicate the country or institution which produced them. P. R. 433 is the variety number 433 of the seedlings grown in Porto Rico by the Federal and Insular Experiment Stations. The first 200 numbers were produced by the Federal Experiment Station.

D stands for Demerara; B for Barbados; St. C. for Saint Croix; B. H. for Barbados Hibrid; GC for Guánica Central, etc.

The Mosaic Disease of Sugar Cane

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History and Extension of Infected Area:

The mosaic disease of sugar-cane, commonly known as "matizado" was brought to Porto Rico in importations of foreign seed on a date which has not been determined. The disease has been known to exist in Java for many years and is found today in practically all the countries having a sugar-cane industry: Cuba, Santo Domingo, Louisiana, Hawaii, Argentine, etc. In Porto Rico, the epidemic showed alarming characters in the Arecibo region, in 1915, and has spread rapidly with more or less intensity, over all the sugar regions of the island.

The epidemic inflicted very severe damage to the sugar industry, and in certain regions it is still a very important factor in production. The effects of the disease do not manifest themselves in the sucrose content of the cane, but affect readily the tonnage of the infected fields.

Symptoms: The symptoms of the disease appear in the leaves, whose surface, instead of being of a uniform green color, show the characteristic mottling. The effects of the disease on the cane stalks begin by a contraction of the internodes, and where advanced it shows the canker stage in which the stalk is stunted and cranked in various places.

Research in Porto Rico: Porto Rico has been the first in America to conduct a scientific study of this disease, and under its insular institutions researches have been undertaken resulting in important discoveries.

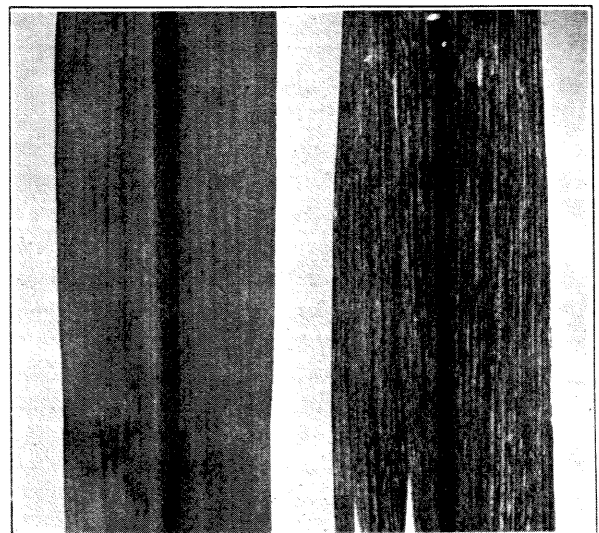
As yet the cause of the disease has not been found, but the idea prevails that it is due to a filtrable virus or to an ultra-microscopic organism. The mineral components of the soil, its chemical reaction or any other soil factor do not affect the disease. The disease has been produced only by injecting diseased juice in healthy canes, thus proving that it is an infectious disease.

Transmission of the Disease: The spread of the disease in the fields takes place in two ways: by the use of diseased seed (primary infections); or by means of aphids (secondary infections). There are two species of aphids that transmit the disease: the corn aphids (aphids maidis), and the "coqui" aphids (*Carolinis Cyperi*) which is found on "Coquí". The corn aphid is also found on malojillo and other common weeds. These small insects, after the weeding of the fields, pass to the young cane plants for a short period of time and transmit the disease from diseased to healthy plants.

Variable Resistance of Cane Varieties: Several sugar cane varieties have shown various degrees of resistance to the mosaic disease, and one of them has proven to be absolutely immune to it. The resistance of the most common cane varieties follow:

Immune variety: Uba or Kavangire (also known as Japanese cane).

Resistant varieties: Java 36, Java 213, Java



RAYAS AMARILLAS CARACTERÍSTICAS DEL MATIZADO APARECEN EN LAS HOJAS. LA DE LA IZQUIERDA ES LA SANA. CHARACTERISTIC MOTTLING OF LEAVES DUE TO MOZAIC DISEASE. NOTE HEALTHY LEAF AT THE LEFT.

228, D-109, D-117, B-109, B-3859, B-6450, P. R. 260, P. R. 292.

Less resistant varieties: Rayada, Cristalina, D-443, B-376, B-4596, Java 105 (Egyptian), St. C. 12 (4), BH 10 (12).

Very susceptible varieties: Cavangerie, Caña Blanca, Yellow Caledonia, B-208, B-3412.

How to Control the Disease: The following measures are recommended in the control of the disease:

1. In very heavily infected regions planters will have to resort to the planting of the immune Uba or Kavangire. In upland soils, this variety will produce as much sugar as any of the standard varieties, and besides,

that it will also yield a far heavier tonnage.

2. In regions of medium infection, a careful selection of seed is recommended and, under all circumstances, plant only healthy seed. Keep the fields as free from weeds as possible. This will eliminate the host plants of the aphids. All new cases of the disease must be systematically removed. In slightly infected regions, this method will give positive results in a short period of time.

These measures have already been tested by various centrals of the island and are given with the certainty that if practiced persistently they will result in the control of the disease within a limited cost.

Two Destructive Sugar-cane Diseases in Porto Rico

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Prevalent Diseases and Their Relative Destructiveness: There were about fourteen different diseases recognized on sugar cane in Porto Rico up to two or three years ago. Among these are included the yellow stripe disease, rind disease (*Melanconium sacchari*), pineapple disease (*Thielaviopsis paradoxa*), red rot (*Collectotrichum falcatum*), root disease (due to various fungi), the various leaf spots and sheath diseases and chlorosis. With good cultural methods the diseases mentioned, excepting yellow stripe, are at present of no economic consideration. The losses which they cause are not noticeable and are really insignificant as compared with the destructiveness of the recently discovered gumming disease and the new dry top rot of the sugar cane.

The first of these two is caused by a bacterium and the second by a fungus of a low type. Both of these diseases cause directly the stunting and death of the cane stalks at all stages of growth.

It is difficult to estimate with any degree of precision the loss caused by either one of them, but it is safe to attribute a reduction of at least 50% in tonnage to the dry top rot disease in

fields where it has become established and about 25% to 30% reduction to the gumming disease at its present status, in fields containing the more susceptible varieties of cane.

These two diseases have been studied for the last three years by the writer at the Insular Experiment Station, Rio Piedras and several papers written concerning their nature.*

I. GUMMING DISEASE

Discovery and History of Invasion: The gumming disease of sugar cane was discovered by the writer in Porto Rico about the beginning of the year 1920 in more or less isolated fields, in an area including the municipalities of Trujillo Alto, Río Piedras, Guaynabo and Morovis. The following year the disease had spread to Bayamón, Cidra, Caguas, Cayey, Aibonito, Corozal and Barros. In 1922 it was found to have extended along the north coast to Toa Baja; in the interior it penetrated to

*Circular No. 20—La Gomosis de la Caña de Azúcar. (Editions of 1920 and 1922.)

Circular No. 56—La Enfermedad de la Raíz de la Caña de Azúcar. 1921. J. Matz. A new vascular organism in sugar cane. Journ. Dept. of Agric. of P. R. Vol. IV., No. 1, Jan. 1920, pp. 4-46, 3 figs.

Adjuntas and from there to the south coast at Tallaboa, Guayanilla and Yauco, westward; while on the eastern end of the island it has been found in the vicinity of Las Piedras, Humacao, Naguabo, Fajardo, Rio Grande and Carolina.

Outside of Porto Rico the disease was recorded to have occurred in epidemic form in Brazil in the year 1863, and again in 1894, when it was active in Australia and Mauritius. In Java there exists a disease of sugar cane known locally as gum disease, but which is not the same as the gumming disease of Australia and Porto Rico.

Symptoms: This disease is best recognized at the time of harvest, by the yellow gummy exudation which oozes out in small drops from the fibers in the cut ends of infected canes. This gummy substance consists entirely of masses of a specific microbe (*Bacterium vascularum*, Smith) and is a mucilaginous product. In the mature laves of diseased cane there may be found dark red streaks running lengthwise of the green blades, and in the inner and more or less unfolded leaves there are light red and brown specks on light green bands or white areas, usually at the basal end, and more often at the margin of the blades.

The diseased areas in the leaves become dry, the older blades split lengthwise, the inner ones become entirely decayed and the growing top of the cane either rots or becomes stunted. The young shoots of infected stools often stop expanding and rot. The older cane stalks may harbor the disease germs in their fibers for some time without breaking down as long as they are not cut. In the leaves the germs enter the growing cells and cause decay.

Effects in Field and Factory: The effects of the gumming disease are reduction of tonnage, poor ratooning, reduction in sugar content, and difficulty in elaborating at the mill.

The disease is caused by a microbe which has been isolated and studied since 1893, and is known as *Bacterium vascularum*, Smith. Since the beginning of the occurrence of the gumming disease in Porto Rico the organism was again isolated and used to reproduce the

disease in order to test the susceptibility of different varieties of cane to it and to find out how the disease is transmitted in the field.

Methods of Transmission: The disease was reproduced in all its typical forms by placing a drop of liquid containing a pure growth of *Bacterium vascularum* on the surface of moist inner leaves of healthy and growing susceptible canes. It is, therefore, evident that no special carrier is needed for the transmission of the disease. Infected cutting instruments, insects, diseased seed or any other possible conveyor may carry it from place to place.

Infection takes place usually thru the leaves where the microbe finds its way into the fibers and thus descends to the stalk. Artificial infection thru the roots did not produce the disease. Neither is the disease transmissible thru the soil, that is, healthy seed may safely be planted in infected soil, and the seed will produce a healthy crop. But when healthy seed are planted together with diseased seed or near a field of diseased ratoons, new infections take place, after the seed has germinated, thru the exposed leaves. The tender stalk is also susceptible to infection.

Variable Resistance of Cane Varieties: This disease is almost unique in its partiality to certain cane varieties. The disease can be controlled, therefore, and eradicated by eliminating the susceptible varieties of cane. The variety Otaheiti is the cane most susceptible to it. This variety takes the disease very quickly and acts as a source for the infection of the less susceptible kinds. There are a number of good cane varieties that are resistant to the disease. Among these are D-109, D-433, D-625, D-117, B-3405, Uba, B-208, B. H. 10 (12), Yellow Caledonia, B-3412, B-6292, B-1809, P. R. 334, P. R. 292, P. R. 333, and many other seedlings. Out of forty-five varieties tested the following took the disease in order of severity: Otaheiti, Calancana, Rayada, Cristalina, B-376, P. R. 491, P. R. 487 and P. R. 358.

How to Control the Disease: It is evident from the rapid spread of this disease and the damage it causes, that negligence on the part of the growers to stamp it out will cost the sugar industry of the island heavy tolls. It can be gotten rid of, by using absolutely healthy seed

which can yet be obtained, by planting only resistant varieties in the infected districts, and by eradicating plants which show disease signs.

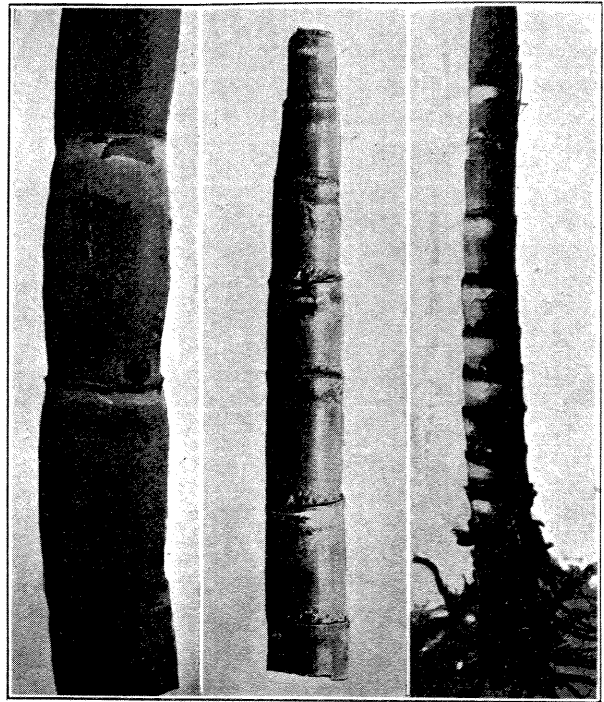
II. DRY TOP ROT

History of Invasion: This disease was not known here until the year 1919; it was detected in the variety Cavangerie or Caña Colorada near Bayamón. Later it was found at Río Piedras, Cayey, Salinas, Guayanilla, San Germán, Yauco, Mayagüez, Añasco, Arecibo, Manatí, Dorado, Toa Baja, and Loíza. This does not indicate that the disease has actually spread to those localities in the order given, it was simply recognized there in fields where cane was suffering from what is known as root disease, top rot, and wilt. So far Porto Rico is the only place in the world where the disease is recognized; however, this does not mean that it does not exist elsewhere.

Symptoms: This disease is really the most serious of all the cane diseases on the island: It causes heavy reduction in tonnage, it is the principal cause of ratoon failure in some of the best lands, it attacks most of the best known varieties, and it works in the canes in an obscure and unnoticeable manner until they are almost mature, when the leaves turn yellowish green and begin to dry up from the interior of the top outward. Sometimes dry longitudinal bands in the inner ribs occur first, but later the whole leaf dies. The canes remain rather stunted and of uneven thickness, that is, they are more or less normal at the base but become gradually thinner towards the top.

In cutting the cane stalk across at the base it is noticed that some of the fibers are of an orange-yellow or orange-red color while the tissue surrounding these fibers is perfectly normal white or slightly creamy. With the aid of a microscope one can see in those colored fibers, either perfectly spherical gold-colored minute bodies, about $14/25000$ of an inch in diameter, or granular masses of the same, of lighter yellow color. This is the organism *Plasmodiophora vascularum*, Matz, which is responsible for this disease.

Transmission: The disease is mostly propa-



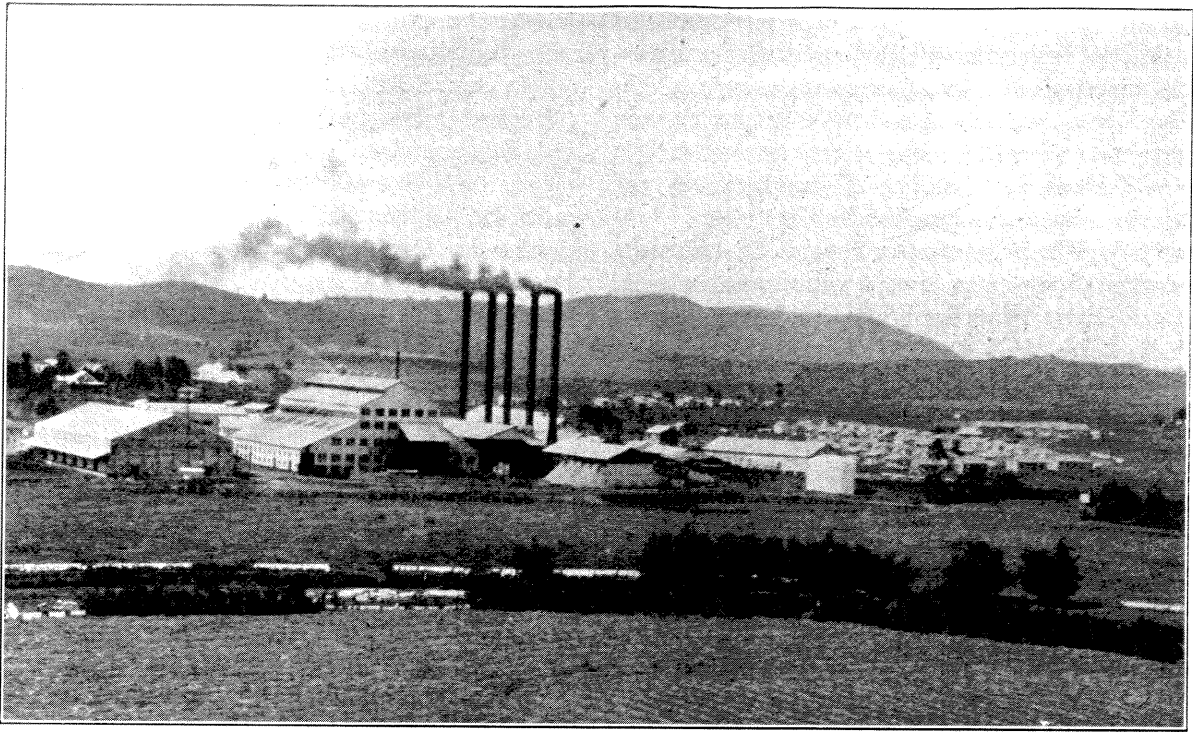
COMPARACIÓN DE UNA CAÑA SANA, A LA IZQUIERDA, CON DOS CAÑAS ENFERMAS DE PUDRICIÓN SECA DEL COGOLLO. NÓTESE EL PECULIAR ACHAPARRAMIENTO Y ADELGAZAMIENTO DEL TALLO.

DRY TOP ROT. LEFT, A NORMAL STALK. RIGHT, DISEASED CANE WITH STUNTED AND THINNER TOPS.

gated through infected seed, and to some extent through the soil, these facts having been found out experimentally at the Insular Experimental Station grounds. Diseased seed produce about 50% infected stalks, and the stalks were less than one-half normal size, and in each stool were a number of dead shoots.

Varieties Commonly Attacked: The varieties of cane most commonly attacked are Rayada, Cristalina, Cavangerie, D-109, Yellow Caledonia and Otaheiti. Apparently this disease attacks a wide range of cane varieties. There are fields of cane much more severely affected than others in the same vicinity, due to the use of diseased seed in the former.

How to Control the Disease: The only measure of control against this disease is to first learn how to diagnose the disease and then avoid taking seed from infected fields. Heavily infected ratoon fields should not be immediately replanted even with healthy seed. A system of rotation, convenient according to local conditions, should be practiced.



VISTA PANORÁMICA DE LA CENTRAL FAJARDO CON SUS CASAS DE EMPLEADOS Y OBREROS.
AN UP-TO-DATE SUGAR MILL—THE FAJARDO SUGAR CO.

The Economic Factors of the Central Sugar Mill

By Jorge Bird Arias,

Economist, Financier, Manager and Vice-President of the Fajardo Sugar Co., Vice-President Association of Sugar Producers of Porto Rico.

The average individual who makes his morning coffee more palatable by the addition of a lump or so of sugar, seldom realizes or stops to think of the vast expenditure of time and labor (mental and physical) that are necessary in order to fulfill his simple and natural request: "please pass the sugar!" We hear a lot of complaining, however, when sugar goes up a few cents a pound, and some hard things said about the "Sugar Barons," but few there are who realize how great a portion of each year their extensive and expensive plants must of necessity be barren of any return to them.

Housewives are loud in their complaints of the high price of sugar when their supply costs them eight to ten cents per pound, but never utter a whimper when they have to pay fourteen, eighteen, or twenty cents per pound for beans, for example, nor stop to consider that

the only plant which they must thank for the beans is the one on which they grew, while for their simple lump of sugar they owe a debt of gratitude to huge, expensive manufacturing plants.

Huge central sugar mills, the product of vast outlay of money and brains, have to work night and day for a comparatively short annual period to furnish the world with sweetness, and then stand idle for the balance, just because mankind demands sugar constantly, and nature only supplies the raw material—cane—at certain comparatively short seasons.

Other articles in this book treat fully of the agricultural features of sugar production, and to the author has been assigned the task of presenting in brief form the economic importance of that indispensable modern food—sugar—the fundamental food value of which

is, however, probably not generally realized any more than are the vast organizations and plants which are devoted to the bringing that fundamental to the dining tables of the world.

An Important Part of Daily Diet. Sugar is an indispensable food for the reason of its food value which, according to dietitians, contains 1860 heat-calories per pound, as compared with roast beef 1110, wheat flour 1640, eggs 635, and whole milk 325.

Various Early Methods. Sugar production in Porto Rico dates back to the early years of the sixteenth century, while that of Louisiana, for example, only reaches back to the middle of the seventeenth, but the great development of the Porto Rico sugar industry only started after the American occupation and the installation of the great modern sugar mill.

The original sugar mill consisted of two vertical rolls through which the cane was passed for the extraction of its juice, and for power, either bulls, water or the wind served the needs of the early day—in fact even today there some wind mills are still in operation crushing cane in the British island of Barbados.

Once this juice was obtained, to convert it into sugar merely a set of open iron kettles were then used, in which the cane juice was boiled into a heavy syrup and then cooled off in large shallow open pans, where it hardened, and presto—one had sugar.

Porto Rico's First Sugar Mill. This was called a muscovado mill, and the first of them was established in Porto Rico near the town of Bayamón in 1548. Later on, naturally, such mills were improved, animal power gave way to steam, and a great many improvements in the apparatus were invented, which made the muscovado mill more efficient up to that point when centrifugal machines were introduced for drying out the sugar so that it could be packed in bags instead of the old-time hogsheads.

Before the American occupation of the island, vacuum pans and evaporators had already been introduced, and were working on some of the sugar plantations of the island, but the real modern sugar factory, or Central, as they

are called, came to Porto Rico with the American flag.

When by virtue of the Treaty of Paris, consequent upon the Spanish-American War, the island passed, in 1900, from the hands of Spain to the possession of the United States of North America, the condition of the sugar industry was untenable, and exportation had decreased in 1901 to 69,000 tons. It was impossible to continue operating the small muscovado plants, some of which still had simply single mills operated by animal power. These small muscovado mills produced from 50 to 1,000 tons of sugar as a maximum, and although there are no exact data from which to determine their extraction and yield, for at that time cane was not weighed before grinding nor were juices analyzed, by comparing one of these small mills with a modern tandem provided with a crusher and four or five mills, it may be safely said that extraction was then not more than 60 per cent of what it is now, nor did the yield in sugar reach 7 per cent.

Efficiency of the Great Central Mills: It became necessary to abandon the small muscovado plants and to construct central mills for the grinding of all the cane in the district. In many cases these new central factories ground the cane of over 20 small plants in one-half the time with an extraction of over 20 per cent in excess and the sugar yield having increased over 50 per cent.

First Central Mills. The first central mills put up in the island were the "Guánica Central" and the "Aguirre Central" on the south coast, both having been constructed by North American corporations. These served as an example and a stimulant to the islanders, who showed great energy in the promotion of new central mills or in remodeling their old ones, so that it may be said that today the sugar industry of Porto Rico is on a level equal to that of the most advanced country of the world.

Advantages to Small Farmers. Before the modern sugar factory came into existence sugar cane cultivation was a privilege of the rich. Only those who had sufficient money to establish a muscovado mill, no matter how small, were able to cultivate sugar cane on

their lands. Now even farmers who own only four or five acres of land will cultivate one or two acres in sugar cane, which they sell to the central factories on the same basis as those who can cultivate on a much larger scale, the railroad which forms part of a modern factory lay-out having made this possible.

Increase in Production. What the increase in the central sugar mills of the island represents may be judged by figuring the value of sugar exported in 1901 and in 1921, on the basis of an average price of four cents a pound, or \$80 a ton.

The 69,000 tons exported in 1901 at \$80 a ton would be worth \$5,520,000. The 450,000 tons exported in 1921, at \$80 a ton would be worth \$36,000,000, the difference being of over \$30,000,000.

Advantages of Large Factories: Modern factories offer great advantages and represent great and positive progress, this being true to such extent that some of them, having been built far from any center of population, have converted deserted districts into splendid towns. No other industry covers a sphere of action so great or employs a more varied number of helpers and professional men, and, therefore, it is one of the favorite industries of the world, since it means welfare and progress.

Concentration of labor brings with it the laying of railway tracks for the transportation of cane from the fields to the factory and of the products of the cane to the ports of shipment, and such concentration also brings with it great improvement in the methods and condition of cultivation, such as irrigation systems, steam plows, soil analyses, scientific use of fertilizers, production of new varieties of cane, and study of, and methods for, the extermination of the different cane diseases. To these we must add complete control of manufacture through chemical laboratories which give an exact knowledge of the

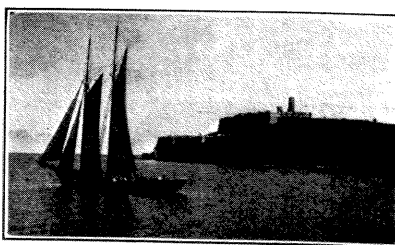
sucrose content in the cane and of the gain and waste, in such manner that any error or deficiency may be immediately corrected.

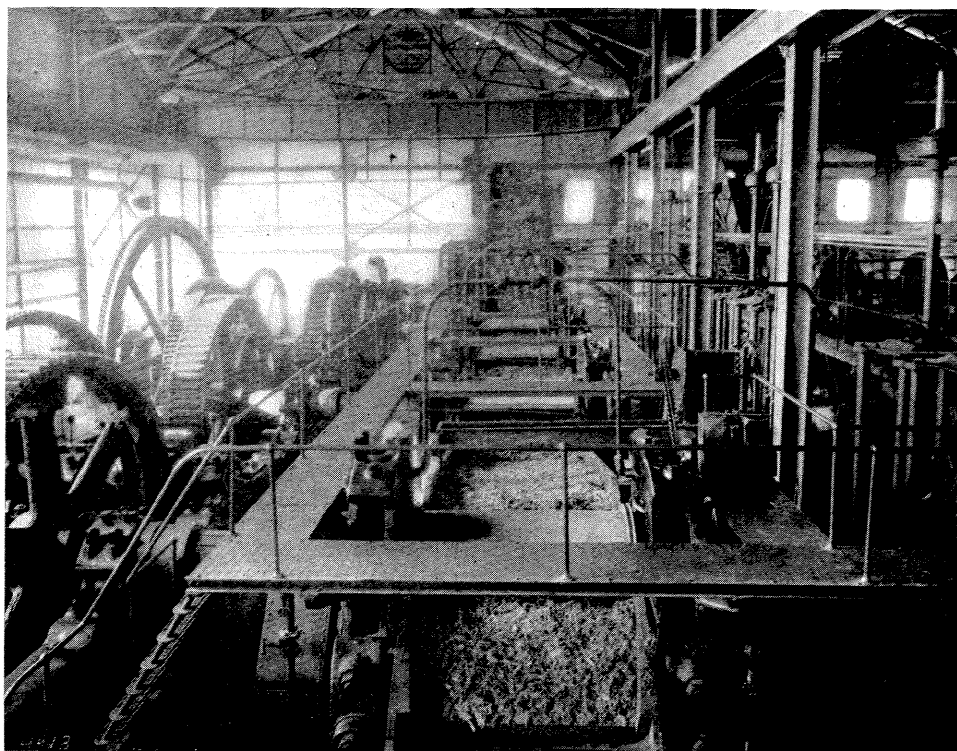
Estimating an average yield of 18 tons of sugar cane to the acre, there are at present 200,000 acres of land, more or less, now used in the cultivation of sugar cane in Porto Rico, a vast acreage for which the island must thank the modern "Central." In fact, it would not be exaggeration to say that the modern sugar factory is the stoutest column of public welfare and the greatest source of wealth and progress on which a community could count.

Extending the Utilization of Power. Owing to Nature and the nature of their product, there are certain comparatively long periods during which both the power plant and the human power of the sugar Centrals stand idle. This is a vital factor of the island's employment problem, and in these days of comprehensive mechanical production and high efficiency, it would seem as if this failure to utilize the possessed power of the Centrals during a large part of each year was not in accord with the best modern practice, and that for the good of the entire island and themselves, ways should be devised whereby at least a considerable part of both their power plant and their workers may be kept busy the year round through their utilization for the production of some bi-product.

In this connection the readers' attention is directed to the article on New Industries in this book, especially that part of it which speaks of the utilization of final molasses, coconut fibre, etc.

Today's Sugar Production. The table given in the Spanish text of this article shows more clearly than words the great growth of Porto Rico's sugar industry since the American occupation, a quarter century ago.





Courtesy of The National City Co., New York

"TANDEMS" DE CUATRO TRAPICHES, MOLIENDO.—MODERN GRINDING OUTFIT.

Sugar Manufacture in Porto Rico

By Francisco López Domínguez, B.Sc.,

Superintendent of the Vannina Sugar Mills. Industrial Chemist. Former Chief Chemist of the Insular Experiment Station. Former Member of the Faculty of the University of Porto Rico.

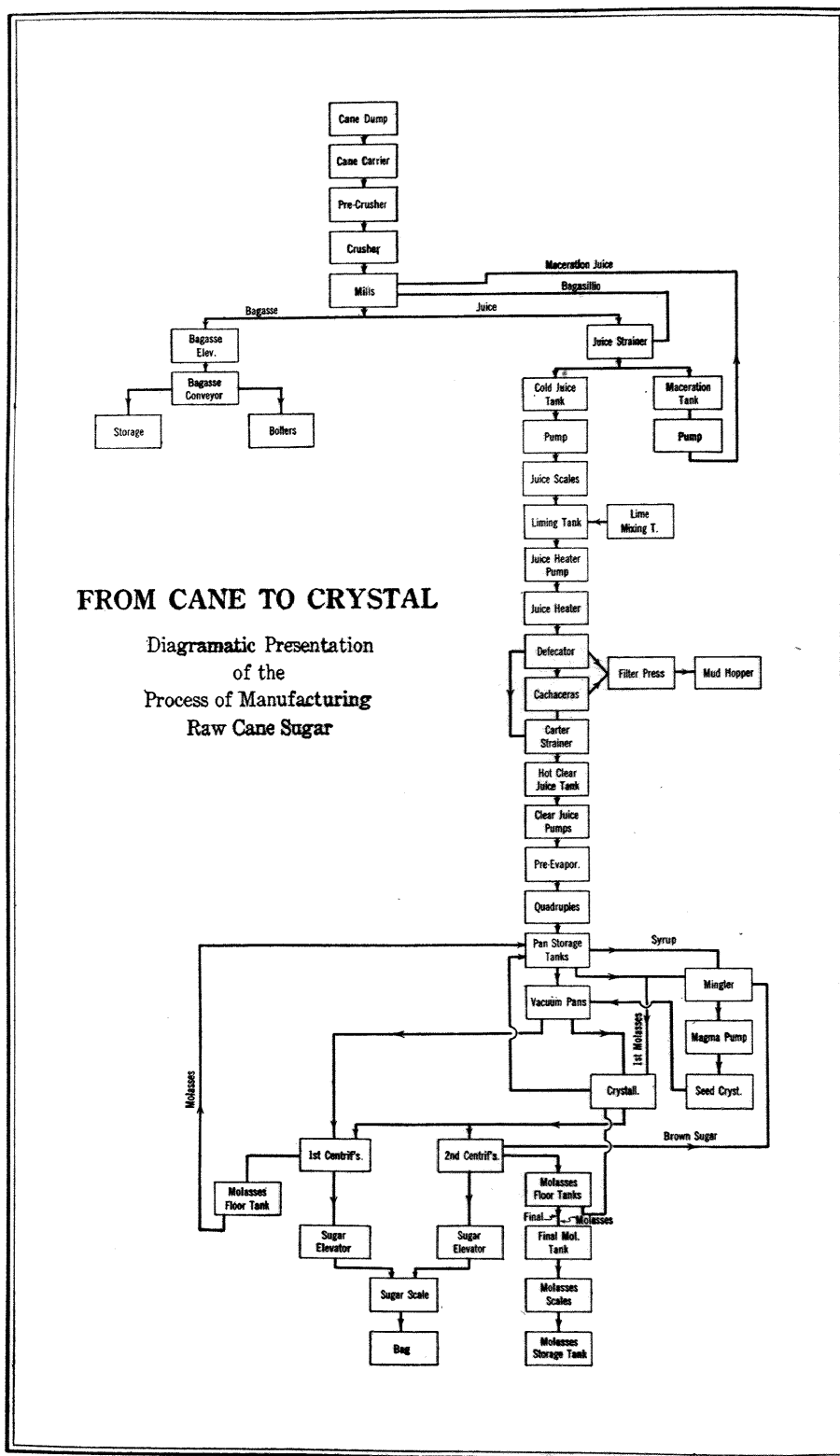
The first ingenios (small sugar factories) were of very simple construction. In the dawn of the industry when it was first started in India in the seventh century, the cane was crushed in wooden or stone mortars by means of pestles, the juice flowing out through a hole in the side of the mortar. This juice was strained through a sieve and then evaporated in shallow pans set on brick furnaces until it attained a semi-solid consistency. This mass allowed to cool in earthenware vessels, or kneaded into balls, was the first sugar made by man.

A Forward Step. After a while the pestle was operated by animal power. This method of crushing cane evolved afterwards into the primitive sugar mill, the first one known in the island of Porto Rico.

The Primitive Mill. This consisted of two or three cylindrical rolls (originally made of wood, and later of iron) placed in a vertical position, connected to each other by means of toothed wheels or gears, so that when one was made to turn on its axis, it transmitted the rotatory movement to the others. These mills also were usually operated by animal power.

The Birth of the Modern Sugar Mill. Later on, the rolls were placed in horizontal position, and steam or hydraulic power was employed to move them. From this type has developed the modern mill. The wooden mills would give an extraction of 30% to 40%, while those of iron rolls reached an extraction of 62%.

Three Types of Early Sugar Mills. Up to 1900 and even later, there were in use in the island three kinds of mills: drawn by animals,



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EXPOSICIÓN DIAGRAMÁTICA DE LAS DISTINTAS ETAPAS EN LA FABRICACIÓN DE AZÚCAR DE CAÑA, DE GUARAPO A GRANO.

usually by oxen or horses; moved by hydraulic wheels of which there were two or three; and those operated by steam, which were the most numerous. There were some places where the bagasse was pressed a second time, either by making it go through the same mill over again or through a second mill in tandem with the first. In the former case the bagasse was received by boys who returned it to the cane platform. In some factories the bagasse was macerated with either hot water or steam before submitting it to a second crushing. The second pressing increased the extraction by seven or eight per cent.

Three kinds of outfits were used in the island at this time, for sugar manufacture, viz. (1) the "tren jamaquino" (Jamaican outfit); (2) the multiple evaporation of the juice under vacuum with centrifugals for separating the sugar crystals from the mother liquor, and (3) the mixed system.

In the last one the juice was evaporated in open pails like those of the Jamaican outfit, the crystallization was made in vacuum pans and the sugar was purged by means of centrifugals. A description of each one of these outfits is given below.

The Jamaican Outfit. The Jamaican outfit consisted of four iron pails, mounted in line on a brick furnace which was charged from the outside with wood or bagasse through an opening in the wall. The flames and hot glass flowed along the furnace, heating the pails on their way to the chimney. Each successive pail was smaller than the preceding one, the largest into which the juice entered first, being that nearest to the chimney. In this pail, called the cachacera (mud pan) and which usually contained about 2,000 liters, milk of lime of about 15°Bé, was added to the juice, the reaction being tested by means of litmus paper.

A different practice was to add the milk of lime in succeeding portions as the juice was emptied from one pail into the other by means of copper buckets known as bombos or bombones. As the defecation of the juice proceeded in the different pails, the supernatant scum was skimmed off with a sort of ladle and emptied into a trough along which it flowed into a tank.

In the last pail, the smallest and the most distant one from the chimney, the juice was allowed to concentrate to 40° or 50°Bé., and was then transferred to tanks where the sugar crystallized out as the mass cooled off. The separation of the crystals from the molasses was effected in vessels or barrels with perforated bottoms, the perforations being plugged with dry banana leaves or bagasse, so that the molasses could drain out through them. This process produced the so-called mascabado sugar, which was packed in the same barrels in which it was allowed to purge. Each barrel contained from 13 to 15 hundredweights of sugar and an outfit like that described above could produce about 15 barrels a day.

The Modern Factory of an Earlier Day. The modern factory of that time was provided with triple-effect and vacuum pan, known as Rillieux apparatus, after their inventor, Norbert Rillieux. Fundamentally these apparatus were like the ones used today, as those installed in Porto Rico were vertical, instead of horizontal as the original ones were. A noteworthy difference between the triple-effects of that time and those used today, was that in the former the juice was heated by steam coils, instead of by the so-called calandria of the modern apparatus.

The defecation and clarification was carried out in these factories practically in the same manner as it is done today. The most important difference was that the old type of defecator had a double bottom, the inner one of copper and the outer one of iron, between which the steam was admitted to heat the juice. The milk of lime was added in the defecators when the juice attained a temperature of 85° to 90°C.

The juice was allowed to decant for ten minutes and it was then drawn out clear by means of taps on the sides, the same as is done today. The residue was discharged from the bottom into a tank where it was allowed to decant once more, and the remaining mud was used for alcohol distillation.

The separation of the crystals from the mother liquor was accomplished in these factories by means of centrifugals, substantially the same as today.

A Greater Renderment of Sugar Possible. With such apparatus a greater renderment of sugar was possible. Usually two, and sometimes three, crops of crystals were obtained from the same lot of syrup. The syrup (cane juice concentrated to about 50°Bé.) was first allowed to crystallize, which produced first sugar, known as "centrifugado de primera" (first centrifugal sugar), the molasses obtained were made to crystallize again, to obtain second sugar—"centrifugado de segunda." Sometimes this molasses was also grained to make third sugars, but this practice was not very common, as it was claimed that it was not economical.

In many places the three grades of sugar were mixed to turn out only one product. The molasses from the third centrifugal sugar was used for alcohol distillation. López Tuero, agronomist in charge of one of the first experiment stations of olden times, estimates that one of these factories would cost about one hundred thousand pesos.

There were some factories where the juices were sulphured, although imperfectly, and a light colored sugar known as "de refino" (refined) was obtained.

According to López Tuero's calculations based on a 100 hectares (254 acres) plantation, the yield would be of 100 hundredweights of sugar per hectare (8% renderment on the weight of the cane) and 133 gallons of rum distilled from the molasses.

Modern Manufacture. As practically all of the modern sugar factories in Porto Rico have been but just recently erected, they are equipped with first class machinery of the latest device. The grinding outfit of the typical factory in Porto Rico consists of three or four mills and crusher so that the cane is first crushed or partially pressed and then subjected to three succeeding pressings, each one at a greater pressure than the preceding one, so that in the last mill the pressure reaches 3,500 lbs. per square inch.

Each mill consists of three cylindrical iron rolls set horizontally, and mounted on steel shafts, the centers of which lie on the vertices of an equilateral triangle. The cane enters the mill between the topmost roll and a side roll

called entrance or cane roll, and the bagasse leaves between the former and the other side roll called the bagasse roll. Between the two side rolls and directly under the top roll, there is an iron plate bridging the space between the tops of the lower rolls known as the turn plate. The turn plate prevents the bagasse from falling between the rolls and helps to keep the pressure on the bagasse while on its way through the mill.

How the Pressure on the Roll is Secured and Controlled. The pressure on the rolls is controlled by means of hydraulic presses in which oil is the transmitting medium. The rolls are grooved around their circumference to promote the outlet of the juice, and to enable them to better grip the cane and the bagasse. The Messchaert grooving, the most efficient for the discharging of the juice, is almost universally used in Porto Rico.

The Crusher. The crusher consists of two cylindrical rolls, set horizontally like those of the mills, with their surfaces roughened by corrugations or triangular edges of various forms and dimensions, according to the manufacturer. The two types most widely used in Porto Rico are the Krajewski and the Fulton, especially the latter.

The rolls of the mills locally used vary in length from 5 to 7½ feet, and in diameter from 30 to 40 inches.

Power. The mills as well as the crushers are moved by Corliss engines. Sometimes only one engine is used to move the whole outfit, while in other instances two engines are used, one for the crusher and first mill, and another for the remaining mills. Both single and double maceration are universally used in the island.

What is Meant by "Maceration." By maceration is meant the addition of water under pressure to the bagasse at the instant the latter leaves the mill; this is done to wash out as much of the sugar retained by the bagasse as possible. With outfits consisting of three mills the water is applied to the bagasse at the outlet of the second mill. When there are four mills the maceration water is applied both after the second and after the third mill, and it is then denominated double maceration.

Sometimes mixed maceration is practiced which consists in macerating after the first mill with last mill juice, and after the second mill, with water. In some factories there are two sets of mills, each set of four mills, which operate simultaneously or alternately depending on circumstances.

Feeding the Cane to the Mill. The cane is fed to the mill by means of a mechanical conductor, known as the cane carrier (locally called "hamaca"). This consists of a traveling floor of boards of about 50 feet in length and 5 inches wide, attached at their extremes to two parallel endless chains which run on rolls or wheels, according to the manufacturer. The cane is unloaded on the cane carrier by mechanical appliances of a variety of forms and construction. At the outlet of the last mill the bagasse is taken up by mechanical conveyors and distributed by them into the boiler furnaces to be used as fuel.

The juice which flows from the mills is then strained through copper or bronze strainers on its way to the receiving tank. The "bagacillo" (small particles of bagasse) held back by the strainer is picked up by a mechanical carrier elevated to the top of the rolls of the second mill and spread on the bagasse mantle going through to be pressed over again. The strained juice is then pumped up to scales specially constructed to be weighed.

The "Liming Tanks." The weighed juice goes to the liming tanks, usually cylindrical in shape, and provided with mechanical stirrers or perforated pipes through which compressed air is blown to stir up the juice and promote the mixing of the milk of lime and the juice. Here milk of lime of 15° or 18°Bé. is added to neutralize the acidity of the juice.

The "Heater." From the liming tanks the juice goes to the heater. This is a cylinder provided with tubes running lengthwise from one end to the other, through which the juice circulates and around which steam flows to heat the juice. The tubes are so arranged that the juice can flow in a given direction only through a limited number of tubes, so that it is compelled to travel back and forth in the apparatus before leaving it. Usually two heaters are used, one following the other, and

the juice is made to travel through both of them. The heated juice at a temperature of about 220°C. goes then to the defecators.

Defecators. The defecators are iron tanks, either square or cylindrical with a copper coil in the bottom to which steam is admitted for heating the juice. On the sides and in succession from the top down, there are a number of cocks or taps which discharge the juice into a trough. The defecator is filled, steam is admitted to the coil until the boiling point of the juice (so-called "cracking point," because the scum floating on the surface cracks) is reached when the steam is shut off. The juice is then allowed to settle, and after a while the clear juice is drawn out by means of the cocks. In the defecator is left the "cachaza" composed of the "bagacillo," the lime precipitate, the albuminoids coagulated by the heat, and other impurities separated from the juice by the action of the lime and the heat. This clear juice is transferred to a tank provided with a straining cloth of about 100 to 150 mesh which holds back a great portion of the finer particles which may have remained in suspension.

The "Cachacera." The "cachaza" or mud is discharged through a wide tube at the bottom of the defecator into another series of tanks (cachaceras) provided with steam pipes for heating the contents and having also discharging cocks on the sides. Here water and milk of lime is added to the mud, and the whole brought to boiling point, allowed then to settle and the clear liquor drawn out as in the case of the defecators.

Then On to Yield More Syrup. The mud remaining in the bottom goes to another tank still, where more water and maybe more lime is added. This muddy mixture is then pumped at a pressure of 50 to 75 lbs. through the filter-presses. The filter presses consist of a series of alternate plates and frames mounted on a very strong frame, all made of iron.

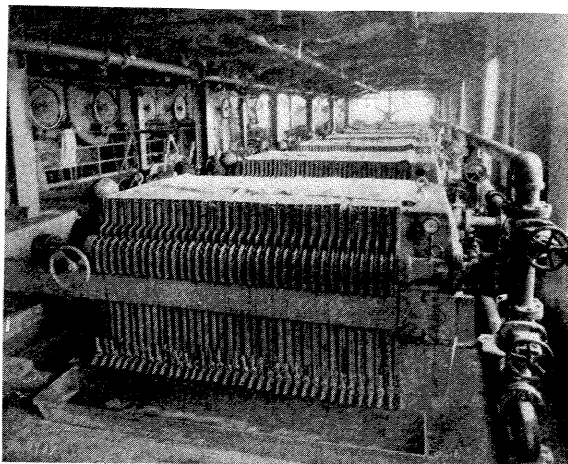
The Filter Presses. The frames are covered with a thick, filtering cloth, especially made for the purpose, and then the plates and frames are firmly and strongly pressed against each other. The muddy suspension enters the frames, the juice filters through the cloth under pressure, and finds its way out to a

trough, by means of small faucets attached to the plates, and to which the juice finds access by small channels provided for the purpose. When the frame is finally filled with the mud which forms in the interior into a hard and compact cake which prevents the further flow of juice, the presses are opened and the mud is discharged. This mud is used as a fertilizer. The filtered juice, as well as that decanted from the "cachaceras" (mud tanks) go to the same tank with the clear juice from the defecators.

The Deming Process. In some factories of the island the Deming apparatus is used for clarification. This apparatus substitute the defecators; it takes the limed juice, heats it, and separates and discharges the mud automatically. There is also one factory where the Corne and Burguireres apparatus is used.

On to the Evaporators. The clarified juice goes to the evaporator to be made into syrup. In Porto Rico the "Standard" triple-effect evaporators are most commonly used. These consist of three vertical iron vessels, cylindrical in shape with dome-shaped tops and convex bottoms. From the top of each vessel a tube of large diameter carries out of the vessel the vapors generated inside. In the lower part of the vessel there is a steam chamber formed by two transverse circular plates, one level with the lower edge of the vertical surface, and the other 3 to 5 feet above the former. These plates are connected by tubes, $1\frac{1}{2}$ to 2 inches in diameter, open at both ends, which connect the upper and the lower division, this chamber with its tubes being known as the "calandria." The juice enters the lower division which acts as a reservoir, and is free to circulate through the tubes of the calandria which connect this lower division with the upper one on top of the calandria, known as the vapor chamber. The circulation is promoted by a tube of larger diameter than the rest, usually placed in the center.

Steam and Juice Both Kept Moving. The steam is admitted to the calandria or mid-chamber, formed by the transverse plates and the tubes, which constitute the heat transmission surface. The vapor chamber of the first vessel is connected by means of the large tube on top, with the calandria of the second vessel, and the vapor chamber of the second vessel,



Courtesy of the National City Co., New York.

PRENSAS FILTROS.—THE FILTER PRESSES.

with the calandria of the third. Thus it may be seen clearly that the steam formed by the ebullition in a vessel is used to heat the juice in the succeeding one. The juice at the same time flows from vessel number 1 to number 2 and on to number 3, its concentration becoming higher in each succeeding vessel due to the evaporation of the water content. The last vessel is connected by the large tube on top to a condenser where the vapors are condensed, thus creating a vacuum. A pump connected to the condenser takes out the incondensable gases and helps to maintain the vacuum. This vacuum is of about 25 to 28 inches in the last vessel (the one nearest the condenser) and is less in the preceding one, where it reaches about 15 inches, and still less in the first (5 to 7 inches), where it sometimes vanishes, as in the quadruple effects.

The Why of These Succeeding Vacuums. These succeeding vacuums cause the juice to flow from one vessel to the other, and make it possible for the steam generated in a previous vessel to bring to boiling point the juice in the succeeding one in spite of the gradual increase in the density of the juice and the heat loss. This is in short the fundamental principles on which Rillieux based the construction of his original apparatus. There are some evaporators in the island with four vessels, called quadruple-effects and even some with five vessels known as quintuple-effects. In some small factories the evaporator consists only of two vessels, known then as a double-effect.

Based on this same principle there are multiple-effect evaporators constructed in a diversity of forms. After the "Standard" apparatus, the "Lille" evaporator is the most common in the island. There are also in use three "Kestner" evaporators, and perhaps as many "Swansons." The juice leaves the last vessel of the evaporator at a density of 28° to 32°Bé. (syrup) and goes to storage tanks from where the vacuum pans take it.

Steam Kept Busy. At the vacuum pans the evaporation is also, of course, conducted under vacuum, which usually varies in Porto Rican practice between 24 and 28 inches. The steam condensed in the calandrias of the evaporators and in the steam coils of the pans is used to supply water to the boilers. In the pan the syrup is further concentrated, until the saturation point is overstepped where the grain forms—crystallization thus takes place. Syrup is gradually admitted to the pan and the grains keep growing at the expense of the sucrose contained in the fresh syrup taken in. When the pan is at last full, no more syrup is taken in, and the mass is further evaporated until a concentration of 90° or 92° Brix is attained.

What "Massecuite" Is. The resulting mass of crystals and molasses known as massecuite, is dumped into a long, narrow tank provided with a mechanical stirrer (the mixer) from where it is distributed to the centrifugals. Here the sugar crystals are deprived partially of the molasses.

The Centrifugals. The centrifugals are a sort of cylindrical basket made of perforated bronze sheet, with open top and a removable bottom. This basket is lined inside by a thick wire mesh, on which is placed a copper-sheet, with very small perforations.

The basket is attached at the bottom to a central shaft and hangs from the free end of this shaft which in turn is supported by an enlargement at the extreme, which rests on ball bearings. The shaft is made to turn on its axis, and in this way a rotatory motion is impressed to the basket, which turns inside a cylindrical stationary casing provided with an outlet to a trough.

Exit the Molasses. The centrifugal force set up by the rotatory motion causes the molasses

to flow out through the perforations in the circular surface into the space between the basket and the casing from where it goes by means of a trough to a tank. The grains too large to go through the perforations are held back inside the basket, where water is poured on them when necessary to wash out excess molasses and bring it up to a polarization of 96°, the standard product required by the market. After the sugar is in the desired condition the machine is stopped, the removable bottom raised and the sugar is loosened from the sides of the basket by means of wooden paddles especially constructed for the purpose, and allowed to drop into a trough with a round bottom.

On to the Elevator. This trough is provided with a screw conveyor which pushes the sugar along and drops it into the receptacle of an elevator which dumps it into a big wooden funnel, and from the bottom of the funnel the sugar is drawn into bags.

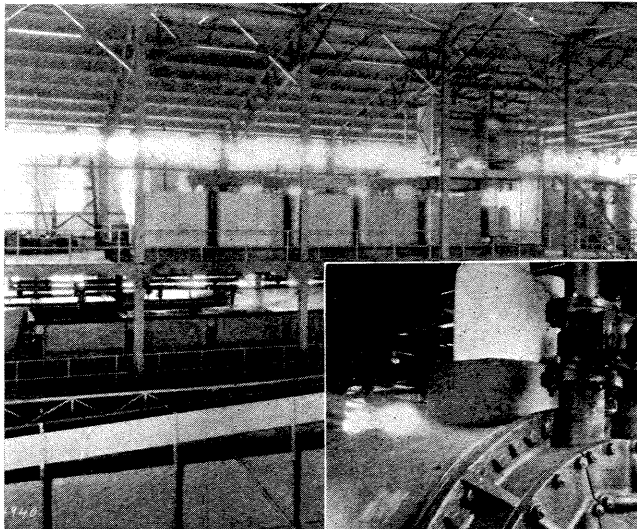
"First Molasses" and "Second Sugar." The molasses obtained from this mass is called syrup molasses or first molasses, and it is used in making second sugar, as follows: a calculated amount of crystallizing syrup is put in a pan, and then molasses added gradually until the pan is filled, and the required total amount of mass thus obtained, is brought to a concentration of 93° Brix, more or less, and then centrifuged out.

"Second Molasses" and "Third Sugar." This mass produces, on being centrifuged, second molasses, used for the making of third sugar. The process is the same as for making second sugar: viz, a given amount of syrup is put in a pan and then second molasses added until the pan is filled. This mass, however, being too poor (55 to 60 purity) to be centrifuged immediately, is allowed to stay in the crystallizers for from three to five days, before purging. By this means, part of the sucrose contained by the molasses is deposited on the grains as the mass cools off.

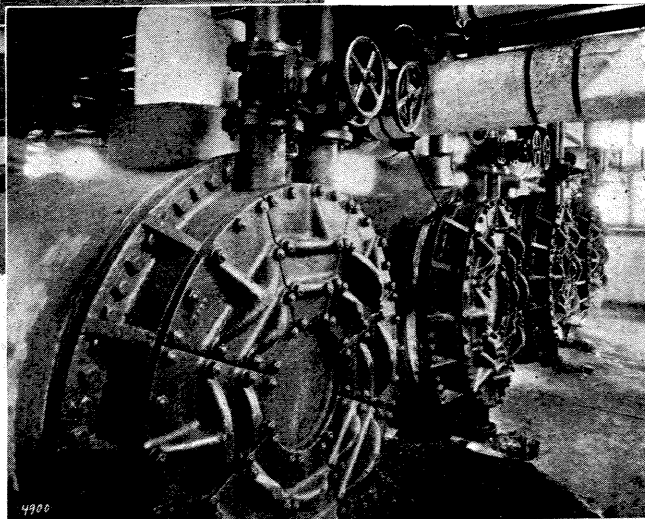
The Crystallizers. The crystallizers are cylindrical closed tanks with an opening for taking the mass, or open with cylindrical bottom and vertical sides, which rest on their circular surface. Through the center runs a

stirrer which keeps the mass in constant motion. This motion prevents the grains from settling, and besides, makes them change their position continually, so that they come in contact with fresh portions of molasses, which promotes the deposition of sucrose. Some

"magma," and this is used as footing in the pan, on which to build first or second masse-cuites. In a very few factories the third sugar is dried out as far as possible in only one purging, and then mixed with the first and second sugars, but the frequent method is that given.



Courtesy of the National City Co.,
New York.



ROMANAS DE PESAR GUARAPO, ENCALADORAS, CACHACERAS Y DEFECADORAS.
TAPAS DE CALENTADORES.—HEAD OF CANE JUICE HEATERS.
JUICE SCALES, LIMING AND SETTLING TANKS AND CRYSTALLIZERS.

crystallizers have double walls, between which hot water may be run to reduce the viscosity of the mass at the time of purging. Usually this is accomplished by adding to the mass either water or molasses solution. When this mass is centrifuged, the resulting sugar is mixed with first or second molasses either in the trough under the centrifugals or in a small mixer.

"Magma." The resulting mixture, known as "magma," is pumped up to a mixer from which it goes immediately to another set of centrifugals to be purged a second time. The second purging produces sugar of about 95° polarization. In some places syrup is used to make the

Rests at Last in Bags. The sugar packed in jute bags containing 250 or 313 lbs. net is transported by railroad or truck, or by both to the nearest port for shipment to the United States.

Prohibition Sometimes Causes New Problems. The final molasses has a purity of 30% more or less, and was used, before the prohibition law was enacted, in the distillation of alcohol. At present some of it is exported, some is used for cattle feed, and a good portion is wasted. In some factories, however, it is being used as fuel but as yet this is only an experiment.

Manufacture of White Sugar. Some facto-

ries in Porto Rico are equipped to turn out white sugar by sulfitation. The outfit usually consists of one or two sulfitation ovens, settling tanks, so-called "bottle filters" of the latest devise, and a granulator.

Many Technical Men Needed. The above described process of sugar manufacture is controlled by competent technical men, mostly natives, and the organization usually adopted is as follows: There is a mechanical engineer, with the required personnel who are responsible for the good condition, upkeep and proper economical operation of the machinery, boilers, mills, etc. A chemical engineer specialized in sugar chemistry, and familiar with the machinery involved, controls the process of manufacture. He is the factory superintendent and in the most important factories is aided by one or two assistant superintendents.

The Chemist Is An Important Factor. The factory control is all based on the data furnished by the chemical laboratory on the raw material, the intermediate products, the final product and the waste materials. Besides, an account is also carried of the time lost and the causes, the time that the vacuum pans take to "cook a strike," and many other data which vary in different places.

Laboratory Work. To carry out the laboratory work there is employed one chemist in charge of the laboratory with the required number of analysts and samplers. Usually the juices of the first and last mills, as well as the mixed juice of all the mills are sampled and analyzed. Also moisture, fiber and sucrose in bagasse are determined.

With these data, the weight of the cane and the weight of the juice, calculations are made for the extraction at the mills, the water of maceration to be added and the amount of sugar lost in the bagasse. Sometimes the maceration water is weighed or measured, with appropriate apparatus, especially constructed. These calculations indicate the kind of work done by the mills and also point out when the mill needs adjustment.

The clarified juice and the syrup are also analyzed, to discover any inversion of the sucrose that may take place in the process of clarification and concentration. The purities

of the syrup and molasses are taken as basis of the calculations made to determine the proportionate amounts of each material that should be taken to obtain a massecuite and molasses of desired purities.

The resulting mass and molasses are in turn analyzed to check the calculations and to control the desaccarification of the molasses. The sugar obtained is polarized as soon as it begins to come out of the centrifugals to determine whether the wash water being used should be increased or decreased according to the grade of the product. If the polarization is over 96° the water should be reduced while if it is below, it should be increased. Besides, a composite sample is taken from each lot of 100 bags by taking a spoonful of sugar from each bag filled and placing these partial samples into a wooden box with lid. When 100 bags have been sampled, the composite sample is taken to the laboratory, well mixed, conveniently prepared and polarized.

How the Quality of Sugar Is Known. The average of these polarizations indicates the quality of the sugar and from them the sucrose contained by the sugar is figured out. The final molasses are analyzed as well to find out the sugar lost in them.

Determining the Loss in the Filter-Press. The sugar lost in the filter-press mud is also determined. When any of the losses exceed the normal limits, the cause is investigated and the trouble removed. A constant effort is always been made to reduce the losses as much as possible.

Close Attention to Every Detail. With the data from the laboratory and the factory a balance is made weekly between the amount of sugar received in the cane, the sugar lost (in the bagasse, the filter-press mud, the molasses and in other forms), and the sugar recovered in crystallized form. Another point to which close attention is given is to the water of condensation of the pans and evaporators as any sugar present in it would cause much trouble at the boilers.

Data Included in the Weekly Report. The data usually included in the weekly report is the following: number of days of grinding; number of hours of actual grinding; number

of hours lost; tons of cane ground; tons of cane ground per day; tons of cane ground per hour; per cent fiber in cane; per cent sucrose in cane; per cent moisture in the bagasse; per cent fiber in the bagasse; per cent sucrose in the bagasse; degree Brix of normal juice; per cent sucrose in normal juice; purity of normal juice; purity of the syrup; per cent sucrose, degree Brix and purity of the exhausted molasses; gallons of exhausted molasses; gallons of exhausted molasses per ton of cane; per cent sucrose in the filter-press mud; normal extraction; dilution per cent cane; maceration per cent cane; sucrose extracted by the mills per cent sucrose in cane; sucrose recovered per cent sucrose in cane; renderment, 96° sugar per cent cane; bags of sugar made and in process of 96° polarization; bags of sugar made; polarization of the sugar; pounds of lime used per ton of cane; tons of crude oil burned per ton of cane; carboys of muriatic acid used; drums of caustic soda. Sucrose amount: sucrose in 96° sugar made; sucrose in 96° sugar in process of manufacture; sucrose in exhausted molasses; sucrose in filter-press mud; sucrose in bagasse, per cent cane; per cent sucrose in undetermined losses; total sucrose per cent cane.

But Sometimes Still Other Things Are Considered. The above data indicate the routine of the control work in most factories. In many, where more personnel and more means are available, the work is carried more in detail. Among other things, the following points receive attention in these factories: all canes coming into the factories are analyzed, to determine the commercial value of the cane proceeding from different plantations or "colonias"; the percentage of moisture and ashes in the sugar are determined to check the work of the centrifugals and the clarification, as well as to have an idea about its keeping quality; observations are made and data taken to gain knowledge as to the efficiency of the work at the crystallizers, at the evaporator, and in fact, all possible investigations so as to ascertain the efficiency of the factory in every respect.

Relation Existing Between Planter and Manufacturer. In closing, it is not amiss to give an idea of the relation existing between

the manufacturer and the planter or "colono." Usually the factories belong to corporations or individuals who plant only part of the cane they grind. Most of the cane is planted by separate corporations or individuals. In the case of the bigger concerns the agricultural corporation may be allied to the manufacturing corporation, and be under the same general management. Nevertheless, in the majority of the cases the factory receives the cane from planters who own their land or have it on lease.

Cane Roads Free to the Planter. The manufacturer constructs and operates a railroad service to transport the cane free of charge to the planter. When the railway has no access to the plantation the cane is transported to the nearest loading station or to the factory by trucks or ox carts, and in such case the planter receives a stated amount per ton of cane per kilometer traveled. Furthermore, in some instances the "colono" is helped by the manufacturer to pay the expenses incurred in loading the cane in the railroad cars. It is common for the factory to make loans to the planters to help them with their planting expenses, the loans being guaranteed by the crop.

Methods of Paying for the Cane. The most common method of paying for the cane up to the present time is to allow the "colono" a fixed percentage of the weight of the cane in 96° test sugar. This percentage varies between 5½% and 7½% depending on the locality, the competition for cane, and the price of sugar. The sugar being delivered to the "colono," bagged at the factory warehouse.

The Manufacturer Selling the Sugar for the Planter. Usually the planters do not dispose of their sugar themselves, but allow the manufacturer to sell it in lot, and then receives the corresponding amount of money according to the selling price.

The New and More Rational Method. A new and more rational method of paying for cane on the basis of its sucrose content, has been established in some factories. For this purpose the juices of the canes sent by each "colono" are analyzed, and from the results obtained, and by the use of formulas prepared to take in consideration the conditions of the fac-

tory concerned, the renderment that each cane may yield is calculated. Of the renderment obtained, 60% to 65% is allowed to the planter.

What the 96° Test Means. The sugar is sent to the United States where it is sold on the basis of 96° test. This means that the product must contain 96% sucrose, and only 4% impurities such as moisture, minerals, salts, glucose and other substances. If the sugar polarizes less than 96° it is subject to a discount if the price offered for the standard, 96° test; if on the other hand, its polarization is over 96° there is a premium paid on the price of the 96° test.

The Author's Object. The author has attempted solely to present a clear, simple description of the process that was used, contrasted with the one actually in use, in the

manufacture of sugar in Porto Rico. This has been written for the benefit of those persons not versed in the technic of the industry; those who have no idea of how an exuberant cane stool comes to be transformed into the sweet crystals which cause at times so much flurry and excitement in business centers. It is not, therefore, intended for technologists in the matter, nor to teach anybody the art and science of sugar making.

In short, the author, in the writing of this article, has aimed to simply give clear information on a phase of the most important industry of Porto Rico in such a way that it may be intelligible, pleasant and interesting to all those who are anxious to know something about the details of that which goes into their coffee each morning.

The Association of Sugar Producers of Porto Rico

By Ramón Aboy Benítez and José Ruiz Soler,

Mr. Aboy Benítez is the President of the Association of Sugar Producers of Porto Rico, a former member of the Insular House of Delegates, the President of various sugar centrals and figures in the large commercial enterprises of Porto Rico.

Mr. José Ruiz Soler is the Secretary-Treasurer of the Association of Sugar Producers of Porto Rico, a former member of the House of Representatives and a former Director of several sugar corporations.

On invitation of Mr. Eduardo Giorgetti, president of the Plazuela Sugar Company, a number of gentlemen interested in the welfare of the sugar industry of the island, met and discussed the plan for forming an association of the sugar producers of Porto Rico and from that meeting came the formation of the Association of Sugar Producers of Porto Rico.

The First Board of Directors. The Board of Directors formed to guide the first steps of the Association was composed of President, Mr. Eduardo Giorgetti; Vice-President, L. F. Vergnes; Secretary, Agustín Navarrete; Treasurer, R. H. Delgado; Counsellors, Messrs. A. J. Grief, P. McLane, Ramón Aboy Benítez, Rafael Fabián, Jorge Bird Arias, Luis Rubert, Federico Calaf, Arturo Quintero and Lucas P. Valdivieso.

Organization Meeting. The Association held its organization meeting in the city of San Juan on February 28th, 1909, in the old hall of the House of Representatives of Porto Rico. The meeting was opened by Mr. Eduardo Giorgetti who stated that he was urged to issue his call by the menace which threatened the sugar industry of Porto Rico, through the revision of the tariff, then being considered by the Congress of the United States.

The First Activity. The Association's first activity was to send to Washington a commission composed of Calagham, Armstrong and Luce, residing in the states, who, together with the representatives of the Sugar Producers of Louisiana, Hawaii and the beet root states, the Porto Rico's Resident Commissioner, Mr. Tulio Larrinaga and Mr. Luis Muñoz Rivera,

the well-known patriot who represented the Island's House of Delegates, should work for the maintenance of the tariff on sugar.

That first commission was later joined by Mr. F. Dexter who, without remuneration, offered his services as consulting lawyer.

Aims. The Association was founded by cane planters and sugar producers with the object of furthering and bettering Porto Rico's sugar industry, comprising the cultivation of cane, manufacturing of sugar and its products; the facilities necessary to the development and transportation of same, the support of Experimental Station and the introduction to the island of choice cane-seeds.

The Agricultural Experiment Station. To Mr. Jorge Bird Arias, the sugar producers, are indebted for the happy idea that they should have their own Agricultural Experiment Station in Porto Rico. Said project was adopted in an assembly held on March 17th, 1910, which decided to install by itself in Porto Rico, said scientific establishment. It was founded in the neighborhood of Río Piedras. The splendid work carried on by the technical personnel of said experiment station has always been acknowledged in the Island and elsewhere, as is asserted by the magazines published in the most important sugar centers of the world.

Owing to the sugar crisis due to the federal legislation of 1913 which placed sugar in the free list, the Association worked and obtained from the Porto Rico's Legislative Assembly the approval of a Jointed Resolution, on March 28th, 1914, which accepted the giving over of the Río Piedras Experiment Station to the people of Porto Rico. Afterwards, several sugar centrals, members of the association, installed their own experiment stations, and their most efficient work has proved to be of great benefit for the sugar interests of the Island.

Various Activities. From the start, the Association has devoted its activities to defend the Island's sugar industry, co-operating with the solution of diverse economical, social and political problems, of general interest for the Island; in many instances sending commissions to appear before the National Finance Com-

mittee of the Insular Legislature and the Public Service Commission, to defend her rights and to benefit the people of Porto Rico.

During the World War it gave unconditional co-operation to the Government for the sale of bonds of the various federal loans, as well as in the several commissions entrusted to it by the governor of Porto Rico. A conservative estimate shows that eighty per cent (80%) of the share of Porto Rico in U. S. Liberty Bonds was absorbed by the sugar producers.

Out of the forty-five centrals of the Island, forty-three constitute this Association. Though the centrals "Playa Grande" of Vieques and "Rochelaise" of Mayaguez nearly a year ago ceased to be members of the Association, their bond-holders have always been willing to help the Association in anything that can touch the sugar industry.

Comparative Data. Due to the great development of the sugar industry under the protection of a federal tariff, and through the work of many men who have been in charge of the most important sugar companies of Porto Rico, the exportation of said product increased from 58,000 tons, the amount exported in 1896-97, the last year of the Spanish regime, to 448,843 tons in 1917.

And it may be of interest to the reader to know that the highest value obtained in such exportations was in 1920, the exportation of that year being of 419,388 tons, of a value of \$98,923,750.

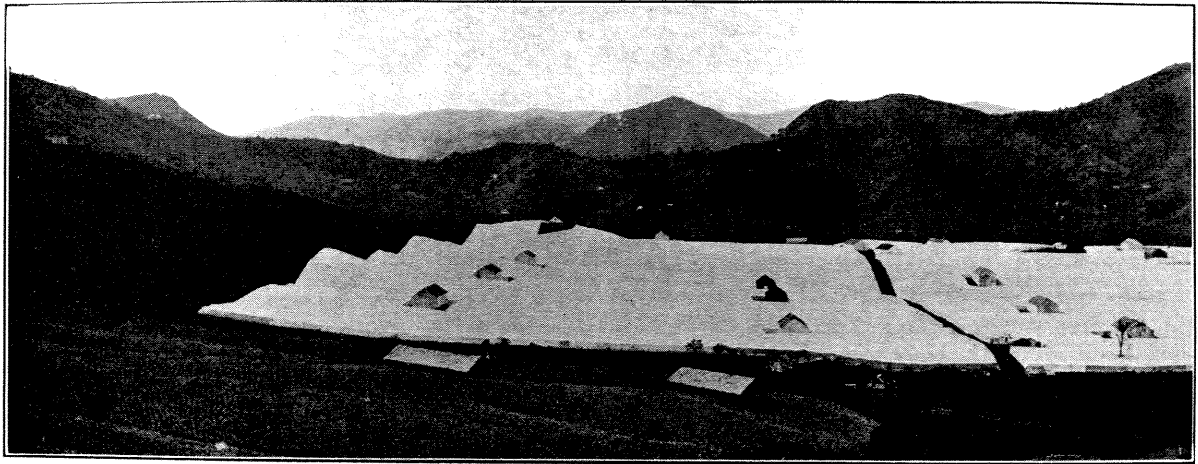
The high prices of sugar in 1920 encouraged the cane producers to enlarge their plantations to such an extent that the exportation of sugar rose to 469,889 tons in 1922 thus ranking first as to quantity in the exportations of sugar and being 50,501 tons more than in 1920, but with the disadvantage that the total of such exportation had a value of \$40,820,333, or that is, \$58,103,415 less than in 1920.

The Status of the Sugar Industry. The above figures show clearly the main cause of the distressing condition of Porto Rico's sugar industry in the last two years, but at present an encouraging view exists. The sugar producers should profit by the present sugar situation by developing a policy strictly conservative.

The present instance is not favorable, as far as can be seen, to start new enterprises as we are in a time of world wide economical reconstruction. The producers, therefore, should be conservative, without forgetting the factors which have benefited the general status of Porto Rico's main source of richness. The Association of Sugar Producers of Porto Rico, true to the aims for which the Association was founded, will go on working for the betterment and protection of the sugar industry, as to do that means to work for the general welfare of the whole island of Porto Rico.

Present Board of Directors. The present Board of Directors is made up of the following gentlemen: Ramón Aboy Benítez, President; Jorge Bird Arias, Vice-President; José Ruiz Soler, Secretary and Treasurer; Counsellors, Eduardo Giorgetti, F. T. Maxwell, C. L. Carpenter, Pedro Giusti, Rafael Fabián, Lucas P. Valdivieso, Andrés Oliver, Damián Monserrat, J. A. Fantauzzi, Gerónimo Vallecillo, Mateo Fajardo, Eduardo J. González, Jaime Sifre and José María González.

Some of these above mentioned gentlemen attended the first assembly fourteen years ago.



TABACALES BAJO TOLDOS EN LAS FERACES VEGAS DEL PLATA.—GROWING TOBACCO UNDER COVER IN THE BEST TOBACCO REGION.

The Cultivation of Tobacco in Porto Rico

By John Frese,

First Vice-President and Manager, Porto Rico American Tobacco Company.

Porto Rican tobacco has been known for years ever since the year 1614, when by a Royal Decree, the inhabitants of the Island were permitted to plant tobacco for commercial purposes. Bishop Torres Vargas writes that in 1646 the quality of Porto Rican tobacco surpassed the quality of the tobacco cultivated in Cuba, Santo Domingo and Margarita (Venezuela).

Spain at that time passed a law that all the tobacco raised in the Island had to be sent to Sevilla, and it was paid for at the rate of two

reales per pound and that same year it produced to the Spanish government the income of 8,000 reales.

It is said that the price paid was not satisfactory for it did not cover expenses. The planters had to look for another market for their product. This they found by trading their merchandise with the English, Dutch, Danish, etc., vessels which touched the Island en route.

In the year 1765 Don Alejandro O'Reilly informed the Spanish government that tobacco

was extensively cultivated in Porto Rico, and it seems that this cultivation produced benefits, because documents have been found which say that the town of Coamo obtained in the years 1760 and 1765 a profit of \$12,000 in the sale of tobacco.

After that certain districts, especially the central ones, were devoted to the cultivation of tobacco, and tried to better its cultivation by means of new methods, and at the beginning of the XIX century it is said that a man named Miguel Perrin succeeded in raising a kind of tobacco of high quality, fine color, soft texture and which burned perfectly. In the year 1826 the island was already exporting the quantity of 26,000 hundred weight of tobacco.

Exportations to Cuba. Increase of Cultivation. The greater part of the tobacco of Porto Rico has always been consumed in the Island. During the years of the Cuban insurrection large quantities of tobacco were exported to that island where they mixed it with the local tobaccos which were famous there. The importation of Porto Rican tobacco in Cuba acquired such large proportions that in the year 1897, when Spain granted the autonomy of both islands, the Cuban Autonomic Government prohibited the importation of Porto Rican tobacco and one year later Porto Rico was occupied by the American Army.

After the Civil Government went into effect they obtained the concession from the United States government to introduce Porto Rican products free of duty, and from that day the cultivation of tobacco has greatly increased.

The New Methods. During the first years after the American invasion the planters had their difficulties, because they did not always obtain for their product prices in accordance with the expense of cultivation. But the demand was constantly increasing and consequently cultivation gradually spread. New methods of cultivation were introduced, the planter gave more importance to the selection of seed and also to the proper chemical fertilizer for the different soils, so that now there is raised in Porto Rico tobacco that competes with the best grown anywhere, and which has a very large market in the United States.

Quality of Soils. The physical conditions of the soils, as well as the climatic conditions are very favorable and the temperature is ideal for the tobacco growing. In the district of Cayey for the last twenty years the average yearly temperature has been 72.7 F., with a maximum temperature of 92 F.

The rainy season is irregular and not as in other tropical countries for example, in the islands of Sumatra and Java where the rainy period is limited to certain months. Sometimes there is an excess of rain; nevertheless the average during latter years has been 71 inches per year and this varies from 2.6 inches in the month of February which is generally the driest, to 8.8 inches in the month of September.*

As tobacco has been planted in the Island for so many years and usually in the same soils, there is no doubt but that a large proportion of the land devoted to its cultivation is somewhat tired and needs the help of fertilizers in order that the yield per acre may render a profit to the planters.

Surely the physical conditions of these lands would be better if the planters gave more attention to this question, giving them a rest for a time, and planting them with legumes in order to give nitrogen to the soil, as well as vegetable matter, or adopting the system of rotation which consists in not planting year after year the same product in the same soil.

The analyses made of the soils devoted to the cultivation of tobacco in Porto Rico shows that the character of the land in general is alluvial in the low-lands and at the river banks, clayey in the more inland part, and calcareous stone, with a vegetable layer, generally of thin depth, in the mountains.

For the reason pointed out these lands consequently are very proper for cultivation of tobacco. The lands of the island especially those of the interior region are distinguished from those of other countries dedicated to the cultivation of tobacco, in that they are free of chlorides. It is known that soils which contain a large proportion of chlorides, produced a kind of tobacco which is almost always dark and burns with difficulty, and as free burning

* For more details on Porto Rico's climate, see the article on that subject in this book.

is an indispensable quality of first grade tobacco, naturally that is a great benefit to the product of the Island.

On the contrary, all the analyses made of the soils of Porto Rico have demonstrated that they contain a great amount of magnesia, which sometimes has influence in the quality of the tobacco.

How Planting is Done. The lands in the interior of the Island are generally mountainous and tobacco is planted on the hills and in the lowlands.

The planting is done more or less in the same way as in other countries. The seed beds are prepared in the best soils, especially in virgin ones, but as these are not now found in Porto Rico, well rested soil is selected. In the months of May and June, the clearing of the land destined for the seed beds begins. Santa Rosa's day (August 30) has been from time immemorial set aside by the planters as the appropriate day for scattering the first seeds.

It has always been difficult to obtain good seeding or "posturas," as they are called in Cuba, surely due in the first place, to the condition of the seed as well as to the little care formerly given to the preparation of the land. In later years the system of making the seed beds under cover has been adopted, that is covering them with cheese cloth in order to keep the soil damp and at the same time protect it against insects. In this way there is more security and generally there is no lack of seedling for the first planting.

The preparation of the seed beds requires special attention. The land must be well prepared making the upper layer as fine as possible, almost ground or pulverized.

The tobacco seed is a very small grain, and so that it may be well distributed and that the grains may not fall down too closely, it is necessary to mix it with ashes or with soil of the same land, before scattering it. Only in this way can one succeed in leaving sufficient space between the grains so that the plant may well develop.

In very wet weather a disease commonly called "sancocho" (phytophthora), makes its appearance and generally it destroys the seed-

beds. This disease can be combated with the "mezcla bordolesa" (Bordeaux mixture), which is a preparation of copper-sulphate and quick lime, and which, used in time, always gives good results.

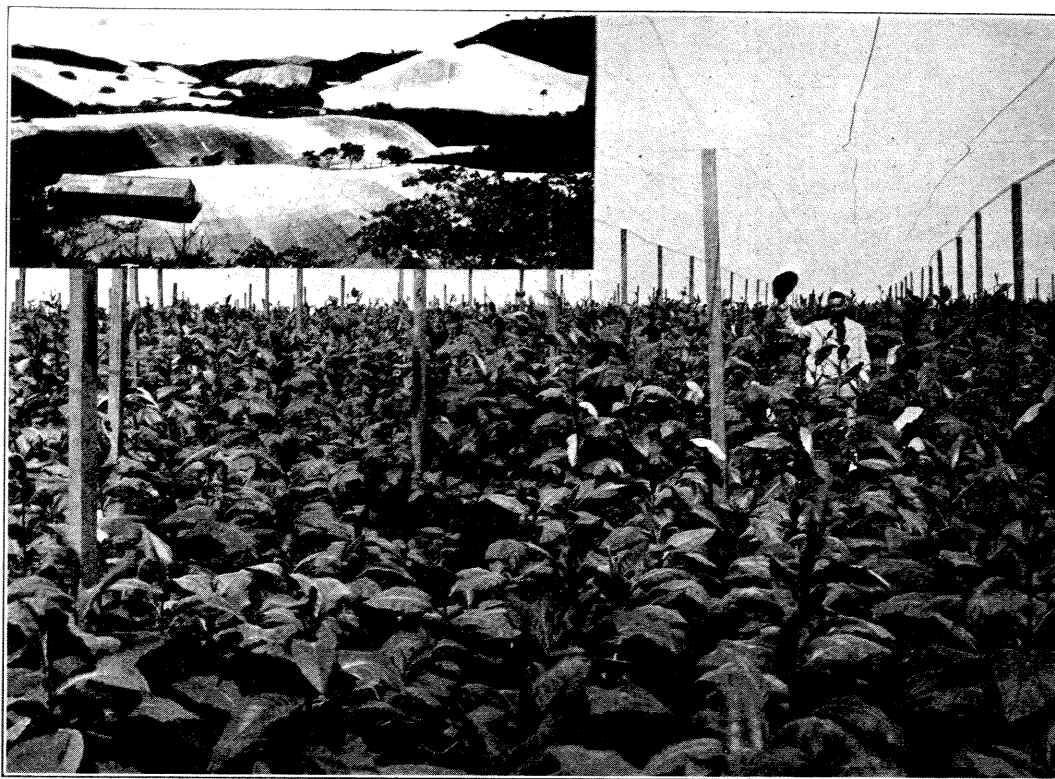
The seeds are scattered at intervals of a week so that they may not all ripen at the same time, and in order to have seedling in good condition during the planting period.

Formerly in Porto Rico it was thought that an acre of seeds was enough to plant ten acres of tobacco. With the help of cheese cloth one can calculate that an acre of seeds will be sufficient for at least twenty acres of tobacco. The large corporations have already discovered that an acre of seed will produce seeds to plant forty acres of tobacco. In favorable weather the seed requires forty-five days for germination and development, and generally in the second half of October, as soon as the seedling are in condition transplanting begins. The land having been previously prepared and conditioned.

In accordance with the conditions of the soil, the farmer applies fertilizers composed of ammonia, soluble phosphates and potash. In Porto Rico the seedling are planted at a distance of 12 to 15 inches apart and from 2½ to 3 feet between rows. After the seedlings have been transplanted it is absolutely necessary to cultivate the lands very carefully, keeping them entirely free of weeds, and in the best possible condition. The large companies and also the chief planters employ mules and oxen in the cultivation, while the small planters still till the land by hand.

As soon as transplantation is ended the planter has to be on the lookout for the insects which cause so much harm to plants. Thanks to the arsenical preparations sold today, the planter can protect his product against that plague. Nevertheless, it gives a good deal of trouble and requires constant attention.

As soon as the plant has reached the necessary growth one must proceed to prune it (caparla), so that all the leaves may have the desired quality. This undoubtedly is the most delicate operation in the cultivation of the tobacco leaf, because it depends on many condi-



CULTIVO DE TABACO BAJO TOLDOS.—TYPICAL SCENE IN THE BEST TOBACCO DISTRICTS.

tions especially climatic, which indicate the time in which the plant must be pruned.

Generally the early tobacco grows more rapidly and ripens at a time during which it commonly rains a great deal in Porto Rico. That ripened in these conditions is deficient in quality, and the plant must be pruned lower than that planted later and which generally ripens in dry weather. In very rainy years all tobacco is as a rule pruned. It is also necessary to avoid the plants giving stems and shoots and all of these have to be taken off in time so that the plant may grow vigorous. After eighty or ninety days the tobacco begins to ripen (the tobacco under cover only needing about sixty days) and then the gathering of the crop begins.

Cutting and Gathering. Twelve or fifteen years ago no other method for gathering tobacco was known than by cutting the whole plant and hanging it with its leaves in drying sheds to be dried out.

In the years 1905 and 1906 by indication of

the buyers, the majority of the planters adopted the system of stripping off the leaves of the tobacco. That is to pick off the tobacco leaf by leaf according to the degree of ripening and gathering first the leaves near the root, later those of the middle and at last those of the top, that is the leaves that form the upper part of the plant.

The principal object of that system is to surely obtain fine wrappers, but for that or any other reason it did not give good results, and satisfactory wrappers were never obtained in open-air cultivation. Perhaps for the lack of experience in gathering the leaves at the precise moment, or because the tobacco did not lend itself to this end, this system greatly damaged the quality of the fillers raised, and experience demonstrated that in years when the weather had not been favorable for cultivation the fillers thus raised were not good, due to little consistency and poor quality.

The planters suffered great losses and the buyers and manufacturers of the United States

justly complained of the quality, and since then they have advocated the system of cutting off the whole plant. There is no doubt that by this system a better quality of tobacco is raised, the body of the leaf being larger and stronger, and it is to be expected that little by little every one will adopt this system.

Construction of the Drying Shed. The tobacco is dried in sheds. This operation is sometimes difficult, especially at the beginning of the crop when the gathering must often be done where there is an excess of rainfall. Generally in Porto Rico all the care required is not given to the construction of drying sheds. There is no uniformity in them, neither as to choosing the most appropriate place, nor are they given the proper orientation against wind and rain. Besides, little attention is paid to cover the shed properly. Straw is without doubt the best covering, but due to the scarcity of that material, the majority of the planters today employ a kind of card board especially made for that purpose. Many sheds are entirely open on all sides, others are poorly closed, and consequently the tobacco suffers in bad weather, the quality suffers, and it does not bring the price that the buyers would have paid had the necessary care been given it.

It is also necessary to protect the tobacco from the sun and the wind. The leaf must not be allowed to be too dry because it then loses in elasticity and quality, and the door of the sheds must not be opened unless it be absolutely necessary. The tobacco dries in a period of twenty-one to twenty-eight days. The leaf is in good condition when the midrib is entirely dried.

Storage and Classification. From the drying sheds the tobacco is sent to the storehouses where it is put in troughs to ferment. In a few days the tobacco gets warm, and as soon as it reaches a certain temperature, the piles are changed and little by little the tobacco acquires the color and smell we all know.

After this fermentation has taken place the tobacco is classified according to quality, and packed in bales for exportation. Formerly all the planters and many merchants used to classify and select the tobacco, packing the

same in bales after the style of Cuba. Today almost all the tobacco is sold as soon as it comes out of the drying sheds, being deposited in the buyers storehouses where they manipulate it in their own way, some stripping off the leaf for exportation to the United States, and others preparing it for the manufacture of cigars on the Island.

Cultivation Under Cover. Lately almost no planter has devoted himself to the cultivation of fine wrappers. The majority of the wrappers raised in the open-air are dark; a color which has today no acceptance in the market of the United States. The large corporations needed wrappers for the manufacture of cigars, and with the purpose of securing every year the necessary quantity they had to recur to the cultivation under cover.

This system was already known in Connecticut and Florida, and in the year 1902 the first experiments were made in Porto Rico in the valley of the Plata river, between Aibonito and Cayey. The result was excellent and for four years they planted tobacco under cover in this same valley, and when the demand increased, the companies were obliged to extend their plantation to other tobacco regions.

Today one can see the installations for this cultivation in Aibonito, Cayey, Caguas, Juncos, Comerio, etc.

The cost of the installation of posts, wire, cloth, etc., is high, but experience has taught that this is, up to the present time, the only way of raising fine wrappers in Porto Rico.

Many experiments have had to be made in order to reach the perfection of today in cultivation under cover, so as to obtain a plant that will give the wrapper required by the market of the United States.

When American interests undertook the manufacture of cigars in Porto Rico, they began to scientifically study cultivation under cover, bringing experts from the United States, Sumatra and Europe, and after much trouble and many difficulties they have succeeded in obtaining the class of tobacco which gives credit to the product in general.

Experiments With Different Kinds of Seeds. The best known and generally most used seed

was that called Virginia Blanca and this is still employed with success in the greater part of the Island. It is a plant of endurance but of small yield. The leaf being long and narrow. Seeds from Florida were introduced for the cultivation under cover. Later was obtained a crossing between this seed and that of the Island, which for a number of years gave a satisfactory result, but the plant degenerated, and experiments were made with other seeds.

From the years 1909 to 1914 extensive experiments were made with seeds from "Vuelta Abajo" and from "Deli," Sumatra, planting them pure and also crossed, but neither the pure seed of "Vuelta Abajo," nor that from Sumatra gave good results, in fact, the first year this result was almost negative, due surely to the lack of acclimatization. From the second year it began to prosper a little, but it never gave a complete result.

All experiments have always shown that the crossings made between the seeds from the different countries give more favorable results. Experiments are constantly being made for the betterment of the class and to obtain plants of endurance and good quality. A seed has been brought from Connecticut called "Round Tip," and the first experiments made have been more satisfactory than the proofs verified up to now with other kinds of seeds. If the experiments for the coming year, which are being made on a larger scale, continued being satisfactory this kind of seed will surely be definitely adopted for the cultivation of tobacco under cover. The first experiences have demonstrated that it is a plant of a greater yield and one which gives a wrapper superior in texture and of fine and clear color.

Increase of Exportation and Prices Obtained. Many thousands of laborers earn their living today in the cultivation of tobacco, which after sugar cane is the most important product in Porto Rico.

The exportation of leaf tobacco to the

United States has greatly increased in the last years, as shown by the following figures taken from the government report:

Fiscal Year	Amt. of Lbs.	Value
1906-1907	4,344,659	\$1,232,058
1907-1908	8,402,286	1,996,055
1908-1909	4,539,320	1,250,237
1909-1910	4,176,172	1,258,317
1910-1911	4,450,012	1,554,783
1911-1912	5,456,751	2,320,130
1912-1913	8,536,776	3,188,227
1913-1914	9,244,490	3,206,610
1914-1915	9,285,333	3,204,423
1915-1916	8,084,914	3,033,149
1916-1917	9,408,723	3,850,670
1917-1918	17,196,323	8,982,130
1918-1919	17,859,559	8,420,583
1919-1920	20,507,565	13,416,388
1920-1921	14,564,394	13,552,587
1921-1922	21,765,553	8,960,400

The prices obtained by the planters in the same period are as follows:

	Per Hundredweight.
1907	\$14.47
1908	14.69
1909	15.78
1910	18.97
1911	21.35
1912	22.60
1913	22.07
1914	17.27
1915	20.05
1916	24.39
1917	34.38
1918	26.24
1919	31.84
1920	54.06
1921	21.93
1922	24.76

These prices are calculated upon the actual sales in the different districts of the Island, according to the price paid including the most inferior tobacco or "boliche."

Cigar and Cigarette Manufacture

By John Frese,

Vice-President and Manager, Porto Rico American Tobacco Co.

Cigar and cigarette factories on a great scale such as those of today, were unknown in the Island, before the American occupation.

Cigarettes have always been made in Porto Rico and exported in small quantities to Europe, and neighboring islands, and in 1897, when Cuba prohibited the importation of Porto Rican tobacco, the first cigarette factories were established in Porto Rico. There already existed a cigar factory in San Juan, whose products had obtained wide fame, but cigarette factories with modern machinery had just began to function and their products for many years were the only ones sold in the Island. All the cigarette factories also used to manufacture cigars, making them in the Cuban style, and especially for local sale.

The American Tobacco Company: In 1900 the powerful American Tobacco Company bought all these cigar and cigarette factories, their first intention being, no doubt, to devote themselves to, and monopolized alone the cigarette business, but as they also took charge of the cigar factories which belonged to the previous owners of the cigarette factories, and as the Island did not offer a sufficient market, having later on the opportunity of introducing cigars free of duty in the United States, they began to send small lots to their general offices in New York, and since that time the industry began to acquire the progress it has today.

The American company, recognizing from the first the good quality and value of Porto Rican tobacco, began an extensive educational advertising campaign all over the United States, spending enormous amounts to introduce the cigar in the market, and as it found acceptance from year to year its sale increased.

This is the industry which relatively employs most people at present. The company constructed buildings of most modern style devoted exclusively to the manufacture of cigars. All the cigars manufactured in the Porto Rican factories are hand made. From fifteen

to twenty thousand persons are employed in this industry, which, not only pays the highest wages to workers but is, at the same time, one of the chief sources of income of the Island's government.

Manufacture of the Tobacco Leaf. The manufacture of cigars and cigarettes requires experience and knowledge. The leaf passes through many hands before it is ready to be manufactured. From the store-house it is taken to another department where it is soaked. Then entirely dried and pressed together in bales. From forty to fifty leaves are tied together in small bunches and they have to be separated before being soaked, because it is necessary that each leaf be loose so that it will take up just the quantity of water it needs.

Then the tobacco is given to the tobacco strippers to be stripped, classified and placed leaf upon leaf, forming small bundles which are put between two thin boards so that the leaf may remain open. Later the boards are removed and the tobacco taken to another department where it is put to dry, this being done more or less according to the quality of each class. Later the tobacco is put in barrels so that it may be more fermented and seasoned.

Experts are in charge of this work and as soon as the tobacco is in condition it is taken to the Mixing Department, where combinations of the various classes are made, in order to obtain the desired quality. Thus prepared, it is conveyed to the cigarmakers' table.

The wrappers go directly from the strippers' department to that of the rezagadores (leaf classifiers) who classifies the leaf according to color, elasticity, size, etc., selecting the fine leaves for the best standard cigars and the least fine for other classes of cigars.

To each cigarmaker is given the quantity of filler required for the number of cigars he is to make and the corresponding quantity of wrappers.

The makers cut off the rim of the wrapper

very slightly, just enough to make it even, and then take up the filler leaf by leaf and adjust it by hand, according to the standard shape they want to make, thus forming the filler (bollo) and then covering it with the wrapper which has already been prepared, and trimming its ends.

As soon as fifty cigars are made they are tied in a bundle and these bundles are collected each evening and taken to the selectors' department, where all the bundles are carefully examined and if there is a defective cigar it is taken out. The cigars are then kept in cedar cabinets and after five or six days are again given to the selectors who classify and pack them.

The selector separates from one hundred and twenty-five to one hundred and fifty different colors and as soon as he has fifty cigars of the same color, he hands them to his packing companion.

The latter separates the cigars for the various layers and as soon as he has packed fifty cigars in the box he puts them in the press. The next day the anilladora bind the rings and the cigars go again to the chief selector to be once more examined; when any defect found is immediately corrected by him, and then they are sent to the shipping department where they are prepared for the United States and where the boxes are trade-marked and sealed with the internal revenue stamps. From five to ten thousand cigars going out from the factories packed in each shipping case.

The cigar sale has increased from year to year in Porto Rico, and each day the cigars obtain greater credit, and to the work done by the tobacco company by so extensively advertising its products in the United States, is due the fact that today Porto Rican leaf-tobacco has found such an extensive market there.

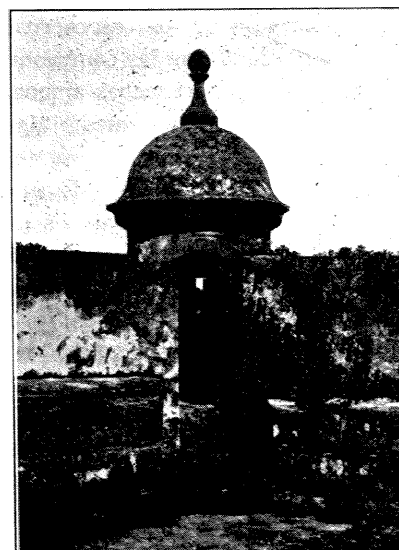
The trade of tobacco stripper is almost an industry by itself, thousands of women and men working in the shops of the Island, and great American and Porto Rican factories are devoted to this work. The leaf is stripped, classified and packed in barrels to be exported to the United States.

Statistical Facts About the Total Production.

The total production of Porto Rican cigars since 1907 according to government statistics is the following:

Year	Cigarettes	Cigars
1907.....	358,182,000	207,368,253
1908.....	365,640,324	180,765,549
1909.....	376,770,000	225,235,531
1910.....	406,986,300	244,424,598
1911.....	471,470,045	275,807,593
1912.....	543,724,350	281,448,271
1913.....	473,768,810	284,806,812
1914.....	382,890,120	263,075,534
1915.....	351,100,915	275,698,490
1916.....	319,811,295	268,379,151
1917.....	.....	.....
1918.....	346,516,640	288,426,204
1919.....	446,693,600	243,459,497
1920.....	581,548,820	311,340,198
1921.....	626,825,760	258,052,041
1922.....	575,126,760	.....

The quantity of cigarettes above mentioned includes also those imported into Porto Rico and the total quantity of cigars produced includes those consumed in Porto Rico and those exported to the United States. According to government reports the consumption of cigars in Porto Rico in the last ten or twelve years is about 100,000,000 annually.



The Association of Tobacco Growers of Porto Rico

By Agustín Fernández,

Agriculturist. Member of the Municipal Assembly of Cayey. Secretary of the Association of Tobacco Growers of Porto Rico. President of the Lodge "Buenas Costumbres No. 20".

The year 1920 was an extraordinary one for the agriculture and commerce of Porto Rico. The agricultural products reached the highest prices recorded in the island's commercial history, the tobacco growers selling their crops at never-dreamed-of prices.

The outlook for 1921 was most promising and credit unlimited. The growers increased their fields; thus making extraordinary expenditures. Few thought, at least for the moment, that increase in production would naturally bring decrease in the value of the product; and the crop for 1921 excelled in quantity all former ones.

Economic Crash. Owing to the economic crash in the last months of 1920, the tobacco warehouse-owners, who at the beginning of the year had acquired their stocks at very high prices, could not sell them with the usual rapidity, and when the 1921 crop was sent to market, the ware-houses were still crowded with the tobacco of the former crop, which was being offered at very low prices. Consequently there was no market for the tobacco of the new crop, and the situation of the growers therefore was very critical. Big financial obligations contracted to raise their crops, threatened their credit, and there was no view of a more promising situation.

The Association Is Organized. Such were the conditions of the growers when the Association of Tobacco Growers of Porto Rico was organized; and the results from the movement, which will not only be of great benefit to the tobacco planters, but to the island as a whole, have not yet been fully reached, the Association being as yet in its formation period.

Objects. The Association furthers the development of the best modern methods of production; to attain the best results in the selection, packing and sale of the tobacco grown by its members; to rent, buy, construct, own,

sell and control buildings and any other real or personal estate which may be necessary for its development; to teach and further the spirit of co-operation in the community and to carry out other tasks for the moral and material improvement of its members.

Various Activities. The directors of the Association have earnestly and unselfishly worked for the improvement of the island's tobacco industry and for the development of the Association, resorting to all proper means within their reach to help the growers out of the critical situation in which they still are.

The Association obtained from the directors of the banks operating in Porto Rico the promise to extend the tobacco growers reasonable terms to enable them to cover their debts without serious difficulty; and the author desires to state that all the banks generously answered such petition giving renewals to the farmers and helping them meet their obligations.

Through the action of the Association the Insular Legislature passed the "Law on Tobacco Stamps" which provides that all packages of leaf or manufactured tobacco must bear pasted on their container a guaranty stamp of the Government, as to the origin of the tobacco in said package. The law also provides the establishment of an office in New York to explain the purpose of the guaranty stamps and to demonstrate the good quality of Porto Rico's tobacco.

Organization. The following data show the importance of the Association and of the production of tobacco in the Island. The Association is organized with a Central Committee whose office is in Cayey, and local committees in Cayey, Caguas, Cidra, Aguas Buenas, San Lorenzo, Gurabo, Aibonito, Comerío, Barranquitas, Naranjito and Corozal.

The Central Committee is at present composed of Messrs. Francisco M. Zeno, president; Luis Benet, vice-president; Arturo Bald-

rich, treasurer; Agustín Fernández, secretary; and Antonio Fernández, Agustín Ortíz, Fernando Pons Zayas and Manuel A. Perez.

The chief tobacco growers of Porto Rico, to the number of about three hundred, are members of the Association, and they cultivate about 25,000 acres of tobacco annually, more than half the total grown on the island.

Tobacco Growers. In 1919, one thousand four hundred and forty four farmers raised tobacco exclusively on their farms, or it was the crop from which they profited the most. If one considers that at that time there were in Porto Rico about 20,000 farmers who devoted their lands to the cultivation of various products, tobacco included; but on account

of the small quantity they raised were not considered as tobacco growers, it is no exaggeration to say that there are at least 3,000 tobacco growers in Porto Rico, employing in their work in the agricultural side of the tobacco industry about 35,000 laborers. The handling of leaf tobacco and the manufacture of cigars and cigarettes employing at least 15,000 additional workers.

Broad Field of Production. With about 50,000 people earning their living in the production of tobacco; if every person out of that number maintains two persons as an average, it is safe to assert that at least one hundred thousand of the inhabitants of Porto Rico secure their living from the tobacco industry.

The Cultivation of Coffee in Porto Rico

By Gustavo Armstrong,

Land Owner and Agriculturist.

Most of the coffee plantations are located in the interior of the Island. The Cordillera Central (Central Range) which crosses Porto Rico in a northwest southeast direction and its ramifications form a very rugged country.

Good Feeder Roads Needed. Due to this feature of the coffee region and the fact that as yet the legislature has been financially unable to provide it with good feeder roads, the Island's coffee districts do not have the necessary means of communication, and this hinders the growers from visiting each other so as to more frequently exchange views on their industry and also from attending the experimental stations in Mayaguez and Rio Piedras, where they could obtain information about modern methods of cultivation, fertilizers and concerning the destruction of plagues injurious to their plantations.

Decreased Fertility of Soil Made New Methods Necessary. Something has been achieved though in the introduction of more modern methods, because the soils not being so fertile as they were ten years ago, the Porto Rican coffee planter has been obliged to improve his methods to meet new conditions.

The Modern System of Coffee Cultivation.

In this article the author will limit himself to the description of the modern system of cultivation of that used by him and others. This embraces: (1) Soils best adapted to coffee. (2) Seeds and planting beds. (3) Transplanting. (4) Cultivation. (5) Fertilizers. (6) Shade. The harvesting and preparation of the grain are described by other authors elsewhere in this book.

Best Soils. The most satisfactory soil is one of heavy texture, containing a high percentage of clay. The clay soils being generally less subject to washing out action than sandy soils, retain humidity better and last longer. Coffee grows well on virgin sand and gravelly soils, but their vitality is soon exhausted and the plantation dies.

Clay soils, being more compact, endure the washing out action of tropical showers, and in dry season possess more water than the sandy soils which dry out rapidly due to their porosity. This clay type of soil, too, seems to offer better bed to the small roots of the coffee shrubs.

The greater part of the soils devoted to the

cultivation of coffee are properly self-drained, though there are some small spots of damp level land that require artificial drainage, to be obtained by digging trenches constructed in accordance with the level of the soil so as to avoid erosion.

Roads necessary for traffic in the future plantation must be laid out before they are planted.

The soil should be well grubbed, taking out as many stumps as possible and should be plowed, spaded or turned over as well. This having been done, if the shrubs for planting are ready, the land is prepared for the transplanting as follows: Holes a square foot in size and one foot deep are dug at a distance of eight feet apart, and when the holes are being dug the laborer must throw the surface earth to the upper side and that from the bottom to the lower side. After each hole is finished the worker must fill it with earth of the surface soil around the hole, tamping same a little to fully fill the hole.

If the grower has to grow his own slips for planting, then the following steps must be taken before he prepares his soil for transplanting.

Seeds and Planting Beds. From a completely developed plantation the best shrubs should be chosen and the best coffee grains, when they are well ripe, selected from them for seed. The peeling of the grains should be done by hand, washing the grains afterwards in water mixed with ash or carbon powder until the sap or juice is entirely washed off so as to leave the grains rough to the touch. They must then be put out to dry in the air, care being taken to see that they do not receive the direct rays from the sun, and when so prepared the seeds can be immediately sown or kept for a few months if desired.

Next the preparation of the planting beds or seed plots must be done. They can be located under artificial shades or under the shadow of young guabá trees. Earth banks three feet wide and from six inches to a foot high, more or less according to conditions, are prepared with side boards of cheap lumber. The earth enclosed in the earth beds must then be well cleaned, spaded, pulverized and

levelled. After the earth beds are ready the seed-grains must be buried with the finger to a depth of one-half inch and at a distance of four inches apart, taking care to eliminate all defective grains and pea bean coffee. At the fortieth day the seed germinates. If the beds have been well fertilized and are kept sprinkled in time of dry seasons to aid the growth, the shoots will be ready to be transplanted about the twelfth or fourteenth month. If seed beds should not be desired, the coffee shrubs growing under the old plantations may be used. These are at present the seeds mostly employed for the sowing, but with them exists the trouble that the kind of seed from which the slips spring out is unknown and this detail is of great importance, it being logical that out of weak seed, a weak slip will develop.

Planting. The planting can be made on any day of the year, provided the soil is wet and the sky somewhat cloudy, for it is not advisable to plant during times of heavy showers or dry seasons.

At the time of the transplanting of slips in the prepared holes of the plantation, a little hole is opened in the center of same with a cane-knife or other implement of the kind, so that the slip or shrub may be placed in it. Care shall be taken that the shrub remains completely vertical and that its main root does not touch the bottom of the hole, and the small lateral roots must be well separated in the hole, in a way that they remain naturally and not entangled. The small hole must be totally covered with earth which is pressed slowly down until the shrub stands firmly.

Cultivation. The procedure of weeding but once or twice a year must be abandoned, it being far more expensive than to weed often, for if weeding is not frequently done the seed of the weed falls to the ground and the soil will always be weedy, thus damaging the coffee plantation. Neat soils yield good crops and the seeds of bad weeds are promptly eliminated.

It is very advisable to till the soil, or to dig small holes well grouped in the space between the shrubs, thus making the soil porous and humid.

Fertilizers. Fertilizers from stables well

cured, or the pulp of the coffee after fermentation has taken place, are much commended, they should be applied in small furrows around the shrub, about two feet from the trunk that is where the roots end, being afterwards covered with earth.

Due to the great varieties of soils in Porto Rico the Experiment Stations have not as yet determined a standard type of commercial fertilizer for coffee. Experiments are being carried on, however, and there is no reason why they should not give definite results.

Shade and How Secured. In order to protect the coffee from the direct rays of the sun, trees which give shade must be provided. The density of the shade required depending on the location of the plantation, the higher it is situated the less shade required.

The shade trees should be planted at double the distance of that of the coffee trees, and if

it is observed that the shade trees are too near one to each other after they have reached their full development, some of them must be removed. As a means of securing temporary shade, while the permanent shade trees which must be provided are developing, banana and plantain trees are used as a makeshift.

The two kinds of trees most often used to give shade are the *guabá* and the *guamá*; the latter being very strong to both winds and diseases, but its shade is too dense, and thus an inconveniency. The *guabá* tree, on the contrary, is not resistant but gives a splendid shade and is easily pruned, it being possible to keep same if desired in the form of an umbrella, if care is taken to cut off the branches which tend to grow upward, but the sunlight easily penetrates through its foliage and the heat of the sun's rays reaches the coffee shrubs direct, which is very injurious to them.

Coffee

Picking, Preparation and Quality

By Samuel Wesley Marvin, Jr., A.B.,

Vice-President and General Manager of Porto Rico Tropical Products Corporation.

The gathering of the coffee crop in Porto Rico commences, in the less elevated sections, as early as July, and continues until February, when the last of the upland product is harvested. On any given acreage there are several ripenings corresponding to the two or three blossomings in the spring, thus making it necessary to go over the trees two or three times during the season, selecting the ripe cherries in the first pickings, and gradually stripping the trees of all remaining berries.

Picking. Men, women, and the more mature children take part in the harvesting. The ripe cherries being dropped into small baskets suspended from the waists of the pickers, and these in turn emptied into sacks, which are transported to the pulping mill by the pickers themselves, or in the case of the larger estates, by mule trains.

The coffee is measured at the mill and the number of "almuds" (a measure correspond-

ing roughly to a five-gallon tin) are credited to the individual pickers. During a good season an able picker can gather eight or ten almuds per day, though the average is about four or five.

Payment ranges from seven to twelve cents per almud, depending on local conditions, and the market price of coffee. Twenty almuds of ripe cherries will produce about one hundred pounds of dried coffee.

Preparation for Market. In the preparation of the coffee for market there are eight principal operations:—pulping, fermenting, washing and drying, usually performed by the producer, and hulling, sorting, sizing and polishing, which are generally done by the wholesale dealers located in the principal cities.

Methods of performing these operations differ greatly, according to the amount of coffee to be handled, the small farmers doing by hand the work that on the larger plantations is ac-

complished by mechanical power. In any case, the purpose is the same. Pulping consists in removing the beans from the pulp in which they are enclosed. A common means is a cylinder with studded copper jacket, which in revolving presses the cherries against a properly adjusted breast, casting the beans forward,

careful sorting out of the inferior or broken beans, and sizing by special machines, the larger beans being considered the most desirable except for the peaberry "caracolillo."

Polishing is customary in preparing the coffee for export, and is accomplished by means of huge steel or hardwood wheels, revolving



LA HACIENDA, LOS RACIMOS Y LAS SECADORAS DE CAFÉ.
COFFEE HACIENDA, COFFEE BUSH AND DRYING PANS, AT YAUCO, FAMOUS FOR ITS COFFEE.

while the pulp is carried away on the studs, dropping into a canal or tank. After pulping comes fermentation, the purpose of which is to loosen the saccharine substance from the beans. Fermenting is allowed to proceed for from eighteen to twenty-four hours. Then, after washing to remove the broken down saccharine substance, the beans, now in their clear parchment covers, are ready for drying.

The coffee may be sun-dried, an operation requiring not less than five days and necessitating, on the larger plantations, extensive cement floors or adequate sets of trays, or the drying may be done artificially by machines designed for the purpose. The bulk of Porto Rican coffee, however, is sun-dried. Hulling is the process of rubbing off the parchment cover and the delicate "silver" membrane that clings to the dried bean. This is followed in the regular commercial establishments by a

rapidly and coming into light contact with the coffee placed in circular wooden troughs.

Quality. Porto Rican coffee is classified commercially as mild, and is comparable in this respect to coffee grown in other parts of the world, outside of Brazil. As in most coffee-producing countries, certain sections seem to excel in the quality of the bean produced, Yauco being the fortunate district in Porto Rico. In general, however, the quality is of the very best, and given the same care in preparation that prevails in the Yauco section, it is undoubtedly true that a uniform Porto Rican coffee could be produced that would rank with the best known varieties of the world.

The island's coffee has long been a favorite in Cuba, Spain and other European countries, to which practically the entire output has been exported in the past.

Association of Coffee ProducersBy **Gustavo Armstrong,**

Land Owner and Agriculturist.

The San Ciriaco hurricane of 1898 destroyed the greater part of the coffee plantations. This misfortune occurred a little after the change of sovereignty, which caused the island to lose the Spanish market to an extent that prices fell from \$30.00 and \$35.00 to \$12.00 and \$14.00 per hundredweight.

The "Unión Agrícola." The idea of association is not new among the coffee producers of Porto Rico, and as the small production, due to the effects of the hurricane, and low prices because of the loss of markets, brought to the growers ruin and wretchedness, and to make matters worse, all the farms were mortgaged. The appalling situation caused a large number of agriculturalists to constitute an agricultural society, the "Unión Agrícola," established in San Juan, Porto Rico.

The farm owners sold their properties to that society for the amount of their tax valuation. The society paid the mortgages on the farms, and paid the balance to the owners in preferred stock, which earned a fixed interest of 7 per cent annually with an accumulative character.

On account of the payment of such mortgages the Association retained the right to raise a loan of from 30 to 40 per cent of the total value of the total farms purchased. The remaining money, after the mortgages were paid, to be used to found and finance an organization for the development and operation of the farms.

The owners of the farms were the farm managers, their capability and efficiency being trusted for such task.

The Association had a life of about three years, and there were many probabilities that the necessary loan would be raised in the United States; but the differences in views among the many farm owners who enrolled as members of the Association, lack of co-operative action from some of the mortgage holders, and finally lack of confidence made the loan a failure.

Something, however, was attained, as an extension of two years for the payment of debts was granted by the Legislature, and the Insular Treasury lowered the taxes on properties, thus facilitating their payment. Two crops were harvested, the financing of same having been paid. The deeds of all the lands were completely cleared and made sound.

When the Society was dissolved the properties were handed over to their original owners with the same obligations they had before joining the Union, and as the coffee planters were thus separated and left without mutual agreements to strengthen their properties, an economic crash was the outcome for many of them in their individual transactions with creditors.

The "Asociación Nacional de Productores de Café." A few years later another organization was founded under the name of "Asociación Nacional de Productores de Café," (National Association of Coffee Producers). Its plans not being as broad as those of the former association, but devoted to the finding of steady and favorable markets for Porto Rican coffee, and easy credit for its members. A crushing mill was also thought of being established for the manufacture of coffee and an official organ was published monthly under the direction of capable journalists. Samples of coffee were sent all over the world, and commissions of members of the Association went to the United States to work for its benefit.

The Association received a hearty welcome from the coffee growers, and had an active life of over four years. It has not yet been dissolved, but is inactive or in what might be called a dying period; the causes being the indifference and lack of faith on the part of the members, and opposition on the part of created interests which felt damaged by it.

"Ligas Agrícolas." These two noted failures, however, have not caused the coffee growers to completely forget the idea of association and they have recently associated in a

local organization called "Ligas Agrícolas" (Agricultural Leagues), which act separately from each other, their by-laws being the same, and having been registered at the office of the Executive Secretary of Porto Rico, under the name of "constituted associations for non-speculative purposes," thus investing themselves with a legal character according to law.

For the purpose of propaganda and mutual information all these leagues have associated and formed the "Federación de Ligas Agrícolas" (Federation of Agricultural Leagues), with offices in San Juan.

Some of them have done good work, agricultural banks having even been established

which operate remarkably well, and the move in favor of such leagues is winning ground every day.

The Agrarian Party. The Porto Rican Agriculturists are starting a movement toward the founding of an agrarian party for the defense of agriculture particularly, and the welfare of the Island in general, striving to assure the fair division of said welfare amongst the towns and rural inhabitants. This party under the name of "El Regionalista" (The Region List), is now being organized in Aguadilla where it is most advocated. Though it is a purely local move, it is one which at the present time has a great many future possibilities.



TORONJALES. OBSÉRVESE LA INFLUENCIA DE LAS FÁBRICAS DE FRUTAS CRISTALIZADAS.
THE EFFECT OF THE CANNING INDUSTRY ON THE GRAPE FRUIT PLANTATIONS.

Citrus Fruit in Porto Rico

By Henry C. Henricksen,

Specialist in Farm Management, Porto Rico Agriculture Experiment Station

The commercial development of citrus growing in Porto Rico dates from the time of the American occupation. Before that the orange, lime and lemon were grown for home consumption but practically none of these fruits were exported. Shortly after the American occupation packinghouses were established in Mayagüez and Ponce from which ports a portion of the oranges produced in the adjacent mountain districts were shipped to New York. That the entire production was not shipped was due

to the difficulty of transporting it. Roads were not then built far enough into the interior to allow wheeled vehicles to enter and of course packing fruit on horseback down mountain trails was not very satisfactory. Also the ships were not fitted for carrying fruit for which reason a great deal of it decayed before reaching New York.

A Bright Future for the Mountain Orange Industry. The mountain oranges were, in years past, as they are now, produced on trees

that were planted as shade for coffee. These trees receive the same cultivation as do the coffee trees and the fruit they produce is of excellent quality. This point cannot be too strongly emphasized. The fruit should be called mountain fruit, not wild fruit. The latter term implies inferiority and the fruit cannot be profitably handled until buyers become convinced that it is cultivated fruit. There is a bright future for the mountain orange industry. Roads have been built, motor trucks have come into general use and ships have been fitted for carrying fruit. Therefore, all of the mountain fruit can now be shipped profitably and undoubtedly the plantings will be extended.

No Reason for Non-Production of Lemons and Limes. Neither lemons nor limes have yet been produced in commercial quantities in Porto Rico but there is seemingly no reason for that. Limes, especially, are produced in some of the West Indian islands under conditions that are similar to those of many districts in Porto Rico.

Early Days of the Industry. Shortly after the American occupation people from the States came to Porto Rico for the purpose of growing fruit. Orange and grapefruit trees were planted extensively in the Río Piedras-Bayamón section as well as in Espinosa plantation section and scatteringly from there along the coastal plain to Arecibo. Some of the early planters had acquired a knowledge of citrus fruit growing in Florida but the great majority started in without practical knowledge of tropical agriculture or horticulture. This naturally led to some individual failures but the industry, as a whole, became stabilized in a remarkably short time. The growers, who had some experience, found that conditions here were different from those they were acquainted with. Instead of being experts they themselves had much to learn. For that reason it is fair to state that the development has taken place because of the accumulated experience acquired in Porto Rico.

A Tip from Nature that Helped the Growers. One of the first difficulties presenting itself was that the trees remained stunted regardless of reasonable care. That was found to be due to a scale insect (*Mytilaspis citricola*) covering

the bark of the young plant and feeding upon the juice. Sprays were used to control it but the results were far from satisfactory.

The Federal Experiment Station was called upon and within a few months a remedy was found. That remedy was pointed out by nature and the man to whom it was pointed out will never forget the lesson. He found that orange trees in the mountain districts were not infected with scale and that the scale could not be made to thrive on those trees except they were exposed to strong winds and dry air. In the moist still atmosphere of the mountain plantations various fungi, to which scale insects are natural food, thrive profusely. In the strong winds and much drier air of the coastal plains these fungi do not thrive. Therefore the remedy naturally suggesting itself was that of creating, on the plains, the same conditions as existed in the mountains. That was done, windbreaks were planted, the little trees responded and they stand today as living witnesses to the value of a clear thought.

Why Grapefruit is Planted in Preference to the Orange. Another difficulty of the early period was that of finding the proper stock for each different soil. Many groves were planted, on light sandy soil, with orange trees budded on sour orange stock. These trees did not thrive and most of them were eventually destroyed. In some of these groves grapefruit budded on rough lemon stock were planted next with satisfactory results. It was also soon found that regardless of the stock upon which it was budded the grapefruit was much more vigorous than the orange. This led to the planting of grapefruit in preference to orange with the result that the grapefruit is the more important of the two at this time.

The Secret of Success. The secret of success in fruit growing is very much like that of any other business, everlasting vigilance, knowing what to do, when to do it and acting upon that knowledge. Unfortunately there are always some unknown factors in every business and also occasionally some that are not controllable. In agriculture the one outstanding factor that is not controllable is that of weather. Fortunately that is not very serious to the fruit growers in Porto Rico, where it is

never too cold nor too hot for the normal development of citrus trees. The moisture is seldom a serious factor. There is occasionally a drought in the winter months but the effect of such can partly be overcome by proper cultivation. The trade winds, which make it so comfortable to live in Porto Rico, do no damage to the trees except such as has been mentioned above. Cyclones may occur but history shows that winds, strong enough to damage fruit trees, do not come very often. The difficulties are therefore not so much the uncontrollable as the unknown factors.

Some Unknown Factors. One such factor, that of citrus scab, asserted itself at about the time the trees began to produce. This has been known for years to attack the trees and the fruit of lemons. The effect of it on the fruit is a rough and sometimes a warty appearance of the rind which makes it almost unsaleable. Scab also attacks grapefruit but not oranges. The loss it has caused to the grapefruit growers can not readily be ascertained but it has been very severe at times. Nowadays it is not so serious because the quality of the fruit is not, in the least, affected and scabby fruit is as valuable for canning purpose as that which has a smooth rind.

No Trouble for the New Grower to Secure Needed Information Now. Some attempts have been made to overcome scab by spraying. It seems probable that it can be, at least, partly overcome if a spray of Bordeaux mixture is used at the right time. Nevertheless it is one of the problems that will never be satisfactorily solved until more knowledge becomes available. Although there are yet many unsolved problems in connection with the production of citrus fruit the fact remains that the man who begins today has the advantage of the accumulated experience of those who began twenty years ago. A sufficient number of laborers have been trained to do the skilled work and even the management of some groves is in the hands of young Porto Ricans. There are but few experts in the business for the development has not yet reached the stage where the industry can support such. But the general knowledge of propagation, planting, cultivation, fertilization, picking and packing is

such that any one engaging in the business now will have no difficulty in obtaining the information he needs.

Plenty of Suitable Land Still Available. There is yet plenty of land in Porto Rico as well suited for citrus growing as the majority of that which is now planted with citrus trees. The sandy soils of the coastal plains are no better suited than are the heavy clays of the interior. Any soil that will produce coffee will produce citrus fruit. But the methods of soil conservation used in coffee plantations must be used for citrus also. Clean cultivation, as practised on the coastal plains is wholly unsuitable on the mountain side. Also shade trees are needed until the citrus become large enough to shade the ground. The system of clean cultivation practiced, more or less consistently, in groves near the coast has, in many cases, depleted the soil of humus. If one or two crops of leguminous plants had been plowed under in those groves each year since the trees were planted many of the troubles encountered could readily have been overcome.

Fertilizers. Commercial fertilizers are being used in all cultivated groves. The three elements nitrogen, potash and phosphorous are needed in all cases. Trees that are not fertilized are not profitable. In some cases commercial fertilizers do not produce the desired result which is usually due to the fact that the soil has been depleted of humus. The remedy is to grow, or to bring in from the outside, such plant material as will produce humus. Also stable manure can be used to good advantage but it can seldom be obtained in large quantities at the present time. In the mountain plantations fertilizers are seldom used but they will be needed for the successful development of a fruit industry on a commercial scale.

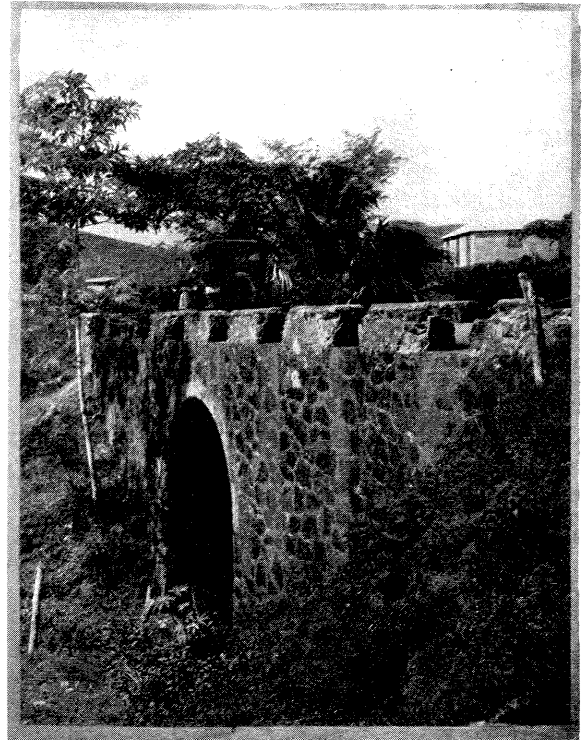
Varieties and Types Grown. The question of varieties is considered less in Porto Rico at the present time, than in other citrus producing countries. The varieties that were planted here, years ago, were not all true to name and many that were have changed, more or less, since then. In grapefruit the main distinction is between the seedless and the seedy. The former is called Marsh Seedless but there are

several different types. The latter is almost invariably called Duncan but there are many types very different from what the Duncan variety is known to be. The Triumph is a distinct variety grown here but it is not propagated extensively.

Distinctions Usually Made. Among the orange varieties that were introduced years ago several can be traced at the present time but they are seldom kept apart in commercial packing. The distinctions usually made are between the Naval and the other round oranges, as well as the Tangerine and the King. The latter two varieties are not commonly planted, neither is there a large acreage of Naval. Among the common round oranges there are two distinct types that ought to be kept apart in the commercial pack, one is round and the other is oblong. Both are found in the mountains and in the lowland groves. But aside from that there are numerous types, some of which are far superior to others, although practically all can be classed as being good.

Solving Shipping Problems. According to the United States Census Report of 1920 there were in Porto Rico at that time but 219,000 bearing grapefruit trees and 114,000 not bearing. The number of orange trees in cultivated groves cannot be ascertained from the census report but it is scarcely more than 100,000 covering about 1,300 acres. In fact the total area planted to citrus fruit amounts to but about 6,000 acres. The acreage would undoubtedly have been much greater if the transportation had grown apace with the fruit industry. For many years the growers in Porto Rico were obliged to ship their fruit in vessels that were wholly unfit for carrying such perishable product. The sales reports frequently showed a decay of fifteen to twenty-five percent on arrival in New York. It was not until 1920 that properly ventilated ships became available. At that time a steamship line undertook to carry fruit from Porto Rico to New York in ships some of which were refrigerated and others that were fitted with forced draft. Since then other lines have fitted up ships with proper ventilation and some with refrigeration.

Necessary Precautions to Avoid Decay. In experiments conducted by the Federal Agri-



EN CAMINO HACIA UNA FINCA DE FRUTAS.
ON THE ROAD TO ORANGE GROVES.

cultural Experiment Station it has been shown that ventilation is all that is needed if certain other precautions are taken. In citrus fruit the maturity changes are not rapid. That is, an orange does not ripen and become soft in a few days after it is picked as does an avocado. Therefore, it can be kept for a long time at a fairly high temperature. Of course, if it is bruised or if the rind is deeply scratched decay takes place, but that can be avoided by careful handling. But the chief loss from decay in Porto Rico's citrus fruit cannot be overcome by careful handling. It is caused by a fungus, *Diplodia natalensis*, which enters the cut stem and causes a decay commonly called stem-end-rot. This decay works very rapidly especially in a hot moist atmosphere such as is found in the hold of a vessel that is not well ventilated. Although this diplodia decay has caused a tremendous loss to the fruit growers in the past they have now no cause to fear it provided they take the precautions of preventing the entrance of the fungus into the fruit. That can be done if the fruit is cut from the tree with disinfected clippers and the cut stem is

immediately sealed with shellac in alcohol. Fruit so treated will not become infected unless it is subjected to conditions like those that prevail in the hot hold of a steamer. With this precaution, together with careful handling and well ventilated steamers, there need be no fear of decay.

The amount of fruit shipped from Porto Rico has, in the past, varied from year to year, as shown in the following table:

ANNUAL SHIPMENTS OF CITRUS
FRUIT FROM PORTO RICO
SINCE 1910.

(According to Customs Reports.)

Year ending June 30.	—GRAPEFRUIT—		—ORANGES—	
	Number of boxes.	Value declared.	Number of boxes.	Value declared.
1910	48,441	\$ 162,749	296,058	\$ 582,716
1911	96,189	309,698	349,442	703,969
1912	118,937	525,048	277,422	584,414
1913	216,247	726,811	353,690	740,091
1914	206,200	751,769	348,927	752,180
1915	276,583	834,440	200,311	378,181
1916	296,645	837,014	404,451	790,797
1917	435,890	939,677	503,318	1,009,737
1918	549,125	1,120,330	603,226	1,231,551
1919	417,369	739,106	373,679	770,303
1920	419,629	1,332,742	336,625	833,575
1921	667,637	2,019,557	162,817	447,426
1922	360,530	1,100,727	388,182	923,912

How the Grapefruit Cannery Solved One Difficulty. This variation is not entirely due to differences in yield. Very often the price determines the amount of fruit shipped and that will be the case in the future, more so than in the past. When the prices are high enough to allow a fair profit over and above the shipping expenses all the fruit, including the low grades, are shipped. When, on the other hand, the prices are low only the higher grades are shipped. That has caused considerable loss in the past but like many other difficulties it has been overcome. There are now a number of canneries that buy and can grapefruit paying the grower as high as \$25.00 per ton for the fruit.

A Satisfactory Process for Canning Oranges Needed. Unfortunately there are no canneries or juice bottling plants buying oranges. A satisfactory process for canning oranges has seemingly not been developed but the difficulties connected with that will undoubtedly soon be overcome. It is interesting to contemplate the changes agriculturally and socially which such a development as that might cause in some of the mountain districts in Porto Rico.

The Pineapple

By Henry C. Henricksen, B.S.,

Agronomist. Specialist in Farm Management, Porto Rico Agricultural
Experiment Station.

Early Conditions and Varieties Cultivated: This luscious fruit is thoroughly at home in Porto Rico. It has been grown for home consumption for many generations, but it has been of no commercial importance until recently. The varieties usually grown twenty-five years ago were sweet, as were all other fruits then grown for home consumption in the tropics. These varieties, among which are the Pan de Azúcar, Caraqueña and Negrita, are yet produced in the mountain districts with little or no cultivation, but the fruit is consumed largely in the district where it is produced. Very little of it reaches the San Juan market and it is not exported except in small lots to supply the demand of West Indians who have recently arrived in New York.

Of the commercial varieties the Porto Rico or Cabezone pineapple gained a foothold fifty years ago, more or less. That is, a small acreage of this variety was cultivated at Palmarejo, a place west of the town of Lajas, a number of years before the Spanish-American War. Attempts were made to export it during the early years, but the results were usually discouraging. The fruit is not a good shipper and it could not be handled successfully with such facilities as were available twenty-five years ago, but with the refrigerated boats of today the Cabezone can be shipped without loss. Its cultivation, however, is yet restricted for it does not thrive well on all soils.

Commercial Development Due to the Red Spanish: The commercial development of

pineapple cultivation in Porto Rico came with the introduction of the Red Spanish variety. This is the one that was produced on the Bahamas and the Florida Keys in early years

apple growing than in citrus growing. In fact, the consensus of opinion among the fruit growers is that the pineapple has been a very profitable crop and is so today.



FINCA DE PIÑAS CERCA DE RÍO PIEDRAS.—PINEAPPLE FIELD.

from where it spread to the peninsula of Florida. It became the favorite plant to grow because it would thrive on soils where other varieties failed, and hence it became the standard market fruit, so that today, to the consuming public, a fresh pineapple means a Red Spanish.

Pioneers in Fruit Growing: When a few people from the mainland settled in Porto Rico after the Island became an American possession it was but natural that they should attempt to apply such agricultural knowledge as they had. To a large number of them fruit growing offered an inducement. The sandy soils of the costal plains, on the north side of the island, seemed to be suitable for fruit growing. The land was cheap, for it was not suitable for cane growing except when sugar prices were abnormally high, and the average Porto Rican did not know how to utilize it for anything more profitable. Unfortunately, many of those from the mainland who engaged in fruit growing also lacked the necessary knowledge, but of absolute failures there were few in Porto Rico compared with those in similar undertakings elsewhere. The failures, or partial failures, have been fewer in pine-

Growth of the Industry During the Last Twelve Years: The figures in the following table give an idea of the production during the past twelve years, but they do not tell the whole story as the volume of fresh fruit exported depends upon the price, and when that is not satisfactory much of the fruit is canned in local canneries:

ANNUAL SHIPMENTS OF PINEAPPLES FROM PORTO RICO SINCE 1910

Year ending June 30	Number of boxes	Value declared
1910	277,058	\$555,044
1911	335,641	641,291
1912	319,096	684,774
1913	360,288	1,142,348
1914	369,952	1,246,001
1915	552,085	1,723,863
1916	532,259	1,176,406
1917	416,550	916,415
1918	145,605	617,496
1919	116,000	458,675
1920	140,906	479,461
1921	172,880	574,640
1922	196,999	600,493

Soils and Fertilizers: It is undeniable, however, that a sharp decline in production took place in 1918, since which time it has again been gradually increasing. This decline in production being caused by erroneous methods of field management. As a rule the soils in Porto Rico are not well supplied with organic matter, and this is especially the case with the sandy soils on which pineapples are usually planted. But as most of these soils had not been regularly cultivated for a long time previous to planting pines, they were in condition to produce a few crops of fruits. When a field became unproductive it was left to grow up with weeds, and new land was planted. But when the time came that there was no more new land to plant, production declined. Also the exhausted fields did not produce so many, nor so vigorous slips for replanting as they did at the beginning, which hastened the decline. The remedy is proper management of the soil, which is gradually becoming better understood, and every year should show improvement.

Some soils are entirely unfit for the growing of pineapples, while others will produce at least three profitable crops in succession. But the latter soils will not produce indefinitely and will not become fit for replanting by leaving them to grow up to weeds, except they be left in the unproductive states for a number of years, and even then they are not equal to virgin soils. Such soils cannot be handled profitably except by such a system of rotation as will add a large volume of organic matter, in the form of crops plowed under, or stable manure applied, or both.

One of the most important factors of field management is that of fertilizing. Fertilizers are indispensable, but different fertilizer ingredients do not produce the same result. In fact, some ingredients are injurious instead of beneficial. This is becoming better understood and the mistakes of the past need not to be repeated in the future. But it may not be amiss to emphasize that in order to succeed a pineapple grower must be mentally awake, as today's knowledge may not be sufficient for tomorrow's need, which means that he must keep himself constantly posted.

(A)

Estimated Production Cost per acre according to Bulletin No. 8 P. R. Expt. Sta. Revised to correspond with today's prices.

10,000 slips at \$20.00 M.	\$200.00
3 plowings at \$6.00.....	18.00
3 harrowings at \$3.00.....	9.00
Bedding the land.....	20.00
Preparing the plants and planting	20.00
10 cultivations and hoeings at \$5.00	50.00
4 applications of fertilizers, 1 ton at \$50.00 plus labor..	60.00
	\$377.00

(B)

Estimated Overhead Expenses per Acre for Two Years.

Interest on land value, say 10% on \$100.....	\$20.00
Interest on working capital, \$400 at 10%.....	80.00
Management	25.00
Buildings and Equipment...	5.00
Taxes and Miscellaneous....	5.00
	\$135.00

(C)

Estimated Marketing Expenses according to Annual Report P. R. Expt. Sta. 1920 (Revised to correspond with today's figures).

Cost per Box	Cents
Picking .....	.07
Box .....	.36
Paper .....	.09
Nails .....	.01.5
Straps .....	.03
Packing .....	.13
Transportation to Wharf....	.15
Ocean Freight.....	.60
Miscellaneous Expenses....	.06.5
Selling commission—8% of an average price of \$4.50 per box .....	.36
	\$1.87

With 258 boxes the marketing expense will be.....	\$482.46
Total Cost per Acre.....	\$994.46

(D)

Estimated Yield According to Bulletin No. 8 P. R. Expt. Sta.—9,000 fruit. Estimated returns according to average sizes and prices compiled from 1918 shipments.

Size	Per Cent	No. of Boxes	Average Price Per Box	Total
16	1	5	\$4.85	\$24.25
18	1	5	4.82	24.10
24	11	41	5.17	211.97
26	2	7	4.99	34.93
30	23	69	5.02	346.38
36	20	50	4.56	228.00
42	17	37	3.92	145.04
48	16	30	3.24	97.20
54	7	11	2.51	27.61
64	2	3	2.17	6.51
			258	\$1,145.99
30,000 slips at \$20.00 M..				\$600.00
Total returns.....				\$1,745.99
Net returns per acre from first crop according to the above figures....				\$751.53

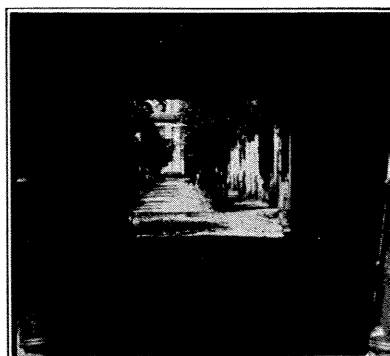
Cost Production and Returns: The cost of producing pineapples does not vary so greatly on different soils and from year to year as does the return. The above figures will serve as an illustration, but it will not be safe to apply them literally to individual fields.

The production cost may readily be 25%, more or less, than the figures here given. The overhead expenses will vary greatly according to the bases upon which they are estimated.

The marketing expenses do not vary greatly, but the per acre expenses vary with the yield. The number of fruit produced is extremely variable, the variation being governed by the quality of the land, and of the plants, the climatic conditions and the management. The price is very uncertain, but the prevailing prices have been good during the past five years. It is readily apparent from table D that the gross returns are governed, not alone by the number of fruits produced, but also by the size of the fruit, both of which vary according to the factors governing yield. The net returns given in the above estimates cannot be obtained except where the soil is well suited for pineapple growing.

Second and Third Crops: After the first crop has been harvested the field may be in as good condition as it was when first planted fifteen to twenty months previously. While the mother plant does not produce another fruit it does produce suckers which, left to grow, will fruit in ten or twelve months. That is to say, another crop can be secured in one year without the expense of bedding, planting and buying new plants. Also under favorable conditions a third crop may be profitably produced, but experience has shown that to be the limit in most cases. On the average sandy soils the second crop is no more profitable than the first one, in spite of the lower cost, and if the soil is especially poor the second crop is not profitable.

How long the field will continue to produce profitable crops will depend largely upon the quality of the soil and also to some extent upon the cultivation and fertilization, in other words, the management.



The Avocado

By J. P. Griffith,

Fruit Grower.

Number and Origin of Existing Trees:

One of the finest of all tropical fruits, the avocado, is widely grown in Porto Rico. The 1920 census showing that there were approximately 161,000 native avocado trees on the Island, 95,000 of which were of bearing age. The markets of Porto Rico are well supplied with avocados for nearly half the year (July to November).

The avocado trees of Porto Rico are practically all seedlings. Many of them have originated purely by chance and are to be found scattered here and there over the Island, and often the trees occur in dooryards of homes where the fruit can be easily gathered.

Like most other fruit, the avocado does not reproduce true from seed. The great mixture of fruit which occurs in the markets of Porto Rico is due to the fact that poor types have been propagated as well as good ones. There has been no selection or other definite line of improvement. To secure the best results with avocados, the trees should be scientifically grafted, using for this purpose only such material as is known to produce fruit of large size and fine quality.

An Opportunity for Export Trade: Under present conditions Porto Rico's avocado crop is satisfactory from the standpoint of supplying purely local markets. Much of the native fruit, especially at the height of the season, is of large size and excellent quality, but if Porto Rico desires to take advantage of her opportunity for developing a profitable export trade, in the avocado, the fruit must be grown and handled in a scientific manner. It is only necessary to mention here, that hundreds of acres are now being planted to avocados in Florida and California. The incentive for such new developments is largely due to the introduction of improved varieties of avocados and to the very favorable prices which American consumers are willing to pay for the fruit.

Improvement by Grafting: Mr. F. W. Popenoe, President of the California Avocado Association, suggests that our inferior trees be

cut back and then top-worked to avocado varieties of known merit. The Bartholomew Brothers, of Garrochales, P. R., have had excellent results in top-working their native trees, grafting into them improved varieties such as those of the Guatemalan type. The grafts not only grow vigorously but also come into bearing early. The Department of Agriculture by employing men who understand the science of grafting could, by following the above plan, greatly improve the quality of the avocado crop in Porto Rico.

High Food Content: The great popularity of the avocado is due not only to its pleasing flavor but also to its highly nutritious qualities. M. E. Jaffa (University of California) finds that the avocado has an average protein content of about 2%, an amount which is greater than that found in any other fresh fruit. Its chief value as a food, however, is due to its high content of fat, which averages around 20%.

Incentives for Developing Export Trade: There are several reasons why Porto Rico is favorably situated for building up an export trade in avocados:

First: The climatic conditions (rainfall and temperature) of the island are naturally suited to their production. There is at no time danger from frost, a hindrance to successful avocado culture in the United States.

Second: Porto Rico has excellent shipping facilities thru the operation of refrigerated and ventilated fruit steamers.

Third: There is an abundance of land which is considered suited to the commercial production of avocados.

Fourth: Labor is both abundant and cheap at all times.

Fifth: A series of hard surfaced roads extending over the Island facilitate transportation and most of the coast lands are served by railroad.

The Three Types of Avocados: Horticultural authorities recognize three varieties of avocados, the West Indian, the Guatemalan and the Mexican. The supply of fruit which appears

on the markets of Porto Rico is all of the West Indian variety. Attempts to ship the native avocado from Porto Rico to the States have not been generally successful. For the most part this has been due to the fact that West Indians avocados have thin skins and loose seeds, making them highly perishable and therefore poorly adapted to long distance shipment. On the other hand the Guatemalan type has a typical thin skin and a seed which fits tight to the fruit. Fruit of the Guatemalan avocado is so well protected that it will carry 15 days or more in transit. This fact together with the high quality of many varieties makes it appear that the Guatemalan is pre-eminently suited as the type for Porto Rico's export trade. There is, however, some question as to whether or not the Guatemalan in its present state can be thoroughly acclimated to the climate. The Guatemalan avocado is indigenous to the highlands of Guatemala where climatic conditions are sub-tropical rather than tropical as in Porto Rico. We are told that many of the types found in the higher elevations of Guatemala have, no doubt, been brought there from their original habitat in the tropical lowlands of that country.

Experimental Work Being Done: Up to the present time eight varieties of Guatemalan avocado have produced fruit in Porto Rico. One of the best varieties of the Mexican type (the Puebla) has also developed fruit on the Island. Wilson Popenoe, Avocado Expert with the U. S. Department of Agriculture, Washington, D. C., expresses the opinion that perhaps eventually, the best shipping type of avocado for Porto Rico will be of hybrid form, a cross between the West Indian and Guatemalan varieties. Already fruit of this character has been produced in Florida and when sufficiently tested may prove to be of great value to the future avocado industry in Porto Rico.

The past few years have witnessed experimentation with improved varieties of avocados at various points on the Island.

The Insular Forestry Service has made a variety test planting of Guatemalan avocados in the hills near Maricao. The Porto Rico Tropical Fruit Company, Garrochales, since 1917, have planted several acres of Guatemalan avocados. At Mayaguez and on the mesas near the town, plantings of improved varieties have been made

by the Porto Rico Experiment Station. There is also a planting at Trujillo Alto. Six varieties of Guatemalan avocados have fruited on the grounds of the Bayamón Avocado Nurseries.

About three years ago, twenty trees of Guatemalan avocado varieties were planted at the Insular Experiment Station, Río Piedras. Recently an experimental orchard of avocado trees has been set out at the Insular Station. This grove includes two Guatemalan varieties and one of the Mexican type. A study of the most improved cultural methods and a record of cost account data (on the acre basis) connected with the expense of producing these avocados, is being made.

While the production of improved avocados in Porto Rico is still in its pioneer stage, careful observers feel that the bulk of the present evidence points towards the successful development of a new and profitable industry for the Island.



"MUSA DEL PARAISO", LINEO.
THE BANANA BEARS FRUIT BUT ONCE.

“Minor Crops”

By Antonio Domínguez Nieves,

Special Teacher on Agriculture. Public School Teacher. Member of various professional associations.

The majority of the tubercles, garden vegetables, cereals and some fruits of Porto Rico used for the nutrition of a large part of the people of the rural zone and of some of those of the urban zone of the island are classified as “minor crops”.

Minor Crops at the Time of the Discovery: When the island was discovered it was observed that the Indians living in the Antille fed principally upon the following “minor crops”: yucca (*Manihot cassava*), sweet potatoes (*Ipomoea batatas*), yautia (*Xanthosoma Sagittifolium*), arum (*Colocasia esculenta*) and corn (*Zea mays*).

Also that though the crops were produced nearly wild and received little or no cultivation, the yield was enough for the nutrition of the natives without importing anything from the adjacent islands. This was unquestionably due, to the great fertility of the soil and the complete absence of insect pests and plant diseases.

Introduction of New Crops: Between the XVI and XVII centuries the banana (*Musa sapientum*), (*M. normalis*), etc., the yam (*Dioscorea alata*) and (*D. sativa*), some garden vegetables and some other crops, now classified as “minor crops”, were introduced in the island.

As the years passed and the island was being settled by the Spaniards, new crops were introduced and better methods of tillage were used, and due to the fertility of the soil, which was nearly all new, the crops grew luxuriously and the yields were abundant. The methods in use, however, were very rudimental, though adapted to the epoch.

By the end of the XVIIIth century and the beginning of the XIXth the methods of tillage had been greatly developed and the production of “minor crops” together with other crops kept the island in a true era of prosperity.

Loss of Soil Fertility: At the end of the XIX century and during the present century the island became nearly exhausted of its flora and the greater part of the soil lost its fertility due to lack of crop rotation, of fertilizers, and of insecticides, etc.; besides the majority of the farm-

ers abandoned the cultivation of “minor crops” to engage in the cultivation of crops which brought them quickly greater sums of money, such as sugar cane (*Saccharum officinarum*), tobacco (*Nicotiana tabacum*), coffee (*Coffea arabica*), etc. These last crops, and especially sugar cane and tobacco, have a great demand both in foreign and native markets and bring large gains to the corporation and big scale planters.

Present “Minor Crops”: At present, the methods used in the cultivation of “minor crops” in the island are far behind the times, in spite of the fact that, the Experiment Stations, the Department of Federal Extension, the Insular Department of Agriculture and the Insular Department of Education are making extraordinary efforts to give proper suggestions concerning agriculture, so that the old methods should be corrected, as due to those now used the yield of crops is not sufficient for the nutrition of all the inhabitants of the island.

Most Important “Minor Crops”: The “minor crops” of greatest importance grown in Porto Rico are: yautia (*Xanthosoma sagittifolium*), yam (*Dioscorea alata*), sweet potatoes (*Ipomoea batatas*), tapioca (*Manihot cassava*), onion (*Allium cepa*), maracas (*Canna coccinea*), arum (*Colocasia esculenta*), beans (*Phaseolus vulgaris*), cowpeas (*Vigna catjang*) gandul (*Cahanus eajan*), chayote (*Sechium edule*), cabbage (*Brassica crececa*), egg-plant (*Solanum melongena*), tomatoes (*Lycopersicum lycopersicum*), pepper (*Capsicum annuum*), lettuce (*Lactuca sativa*), corn (*Zea mays*), rice (*Oryza sativa*), banana (*Musa sapientum*), plantain (*M. paradisiaca*), avocado (*Persea gratissima*) and bread fruit tree (*Artocarpus incisa*).

Soils and their Preparation: The best soil for planting tubercles is one of clay sandy loam, light, porous and with a coarse layer of humus. The soil may contain some moisture, but in such a form as not to cause the decay of the tubercles. For garden vegetables, different kinds of soils are used, but clay sandy soils are most suitable

for planting cereals. The banana, avocado tree, and bread fruit tree grow well in moist clay soil far from the sea.

A careful preparation of the soil is needed, and the old "wood" plow should be eliminated. Plow with reversible plows and where it may be impossible to use them, the use of implements which break the soil in accordance with the thickness of its tillable layers, are necessary. It is absolutely necessary to pulverize carefully the soil and to make a good system of drainage.

How to fertilize: Before planting "minor crops" the soil must be fertilized with green manures, stable manures, manures from the "composts" or with chemical fertilizers. Leguminous plants prove excellent green manures if they are buried in the soil two or three months before planting. Not having a good quantity of green manure at hand, the application of chemical fertilizers is necessary, and it is recommended, to follow the suggestions of the agricultural experts or of the Experimental Stations when applying such fertilizers. •

Amendment or Liming: Sometimes the soil becomes acid (sour) and the crops do not improve in it. This acidity in the soil can be controlled

with an application of lime, from one to three tons per acre applied during the first plowing two months before planting for a period of four years.

Planting: It is indispensable to use special care in choosing the right time for planting and to remember that planting is subject to changes according to the different districts and zones of farming of the island. Generally speaking, however, the months from January to May and from September to December are the best adapted for planting "minor crops". Plant the crops in straight rows and at proper distances. During long drought or heavy rain planting should not be done. Cloudy days or days of scanty rainfall are the best.

Cultivation: Cultivation must be frequent to control weeds. Insect pests which destroy some "minor crops" must also be controlled by means of insecticides such as Paris green, Arsenate of lead, etc.

Harvesting: Crops should be harvested when they are in the right condition for the market. That is, crops which are preferred green in the market must not be sent there ripe, and those which are preferable when ripe must not be harvested green.

Ornamental Plants

By F. M. Pennock, B.Sc.,

Expert on Landscape Gardening. Fruit and Ornamental Plant Grower. Former Professor of Botany and School Gardening, Normal Department, University of Porto Rico.

This brief article aims to be suggestive and practical rather than comprehensive and scientific, and is intended to assist the lover of nature in making a wise selection for ornamental planting in Porto Rico.

Ornamental Trees. The most outstanding ornamental plants are trees. No garden, however small, is complete without a tree.

Cocoanut palms, with their waving fronds, skirt the coral beaches, the massive scarlet trusses of Royal Poincianas (Flamboyantes) dazzle the eye upon the streets, the gigantic Ceibas, or silk cotton trees, with their radial buttressed trunks, and the Pithecolobium saman with its immense stretch of airy shade, are Porto Rico's giants.

Near the sea, the Almendro (tropical almond) the sea grape tree, *Cocolobis uvifera*, the *Casurina equisetifolia*s, recently imported (sometimes called el pino in Porto Rico), are well fitted for the proximity of the ocean.

God made Porto Rico a garden, and it is her people's task to preserve and augment its marvelous natural beauty. Does not the favorite poet of Porto Rico, José Gautiér Benítez, say of her:

"Borinquen, that summons a sweet air
Of vanished love, like an old bridal robe,
Of our America the garden fair,
America, the garden of the globe."

The Island's most graceful growing forms are the great plume-like grasses, the giant

bamboos, which line her rivers and streams, and form with sea and mountain, the picturesque frame of many a rare landscape. Among the foothills and mountains, the queen of trees is the royal palm. Equally beautiful but with a grace more delicate and slender are the tree ferns of the genus *Alsophila*.

The *Trinax* Palms, of which there are three native species, grow in some of the high regions and are worthy of cultivation for their beauty. They are slender-stemmed, fan-leaved trees.

Some of the island's fruit trees are objects of beauty in the landscape. The dense foliaged mango, with its lustrous clusters of lanceolate leaves, the tamarind with its pendulous branches and compound fernlike leaves, the mamme, tall and staunch with thick, shiny oval leaves, the pomarosa or rose apple and the jobo are a few among many of this class, that may well adorn a lawn or border, or be combined to form windbreaks for the shelter of weaker and more wind-susceptible plants. The Porto Rican Roble (*Tecoma pentiphilla*) is one of her best park and street shade trees.

Small Trees and Shrubs. Among the smaller trees and shrubs suitable for lawn groups and the background of borders, are an immense list to select from, only a few of which can be named. Of introduced palms, *Areca lutescens*, or Chinese fan palm, *Latania bourbonica*, and the rare and beautiful *Phoenix Roebeleni*. Also of palms requiring shade, the *Kentias Bellmoriana* and *Fosteriana* and *Cocus wedelliana*. The *Cycas* and the various *Agaves* as well as the different kinds of *Pandanus* are in this class, and are plants that resist wind and dry weather.

The taller *Dracaenas*, especially the rich gold banded *Dracaena Massangeana*, are very ornamental. Other varieties, notable for their rich and varied coloring, are the *D. Tricolor*, *D. Pink superba* and *D. Amabalis*, *D. Imperialis* and the smaller shade-loving kinds, *D. Godseffina* and *D. Sanderiana*.

Other foliage plants of striking variety in color and form of leaf, are those called by American florists "Crotons," of which the twisted-leaf variety, known in Porto Rico as



"CAPRICHOS DE CRISTAL", SANTOS CHOCANO.
WILD ORCHIDS. (ORIGINAL DRAWING BY DR. STAHL.)

Tirabuzón or corkscrew, is an example. These plants may be planted to produce a harmonious color contrast, make very satisfactory formal beds or border hedges, and are so employed in many of the handsome grounds in Santurce, and other parts of the Island. It is possible that Río Piedras has in its plaza the largest number of varieties of any town in Porto Rico, the gift of its generous and learned citizen, Don José Monclova.

Roses. The rose, "The Queen of flowers," has been hybridized from many, distinct species, and each year new varieties, some of great merit, are introduced by the rose specialists of France, England and the United States. The rose does well in all wind-protected localities of the Island, but it flourishes best among the hills and mountains. Varieties of the classes of Teas, Hybrid-Teas and Hybrid Perpetuals succeed best in Porto Rico. Roses love the sun. The soil should be rich, well-drained

of posts and covered, both roof and sides, with narrow strips of lath, having alternate vacant spaces between them for the admission of a portion of the sunlight, are most desirable for this purpose.

Books. Space does not permit including here a bibliography of our general subject, but for the assistance of those who desire to study ornamental plants, both from the scientific and the practical standpoint, it is desired to call the attention of the reader to the monumental work of Prof. L. H. Baily, *The Cyclopedia of Horticulture*, which consists of over 3,600 pages, the labor of over 400 specialists and is beautifully and adequately illustrated. It is published by The Macmillan Co., New York.

Peter Henderson's *Handbook of Plants in one large volume*, published by The Orange Judd Co., New York is a valuable compendium written by a successful florist and seedsman of the North.

The *Handbook of Tropical Gardening and Planting* by H. F. Macmillan, and published by H. W. Cave & Co., Colombo, Ceylon, is a book of great merit for the ornamental planter in Porto Rico.

The Garden of America. Recurring to her poet's phrase, "the Garden of America," let each inhabitant of the Island resolve to do his part to cherish and increase, not injure or destroy, the lovely features and living objects of grace and beauty which nature has so lavishly bestowed upon Porto Rico; to cooperate in beautifying by appropriate planting, not only of home grounds but those of the schools, the public parks, plazas and roadsides. Also understand that a tree or plant once planted, or



ALMÁCIGA DE PLANTAS ORNAMENTALES.
SLAT ROOF PLANT HOUSE.

adopted from nature, has its right to room and hospitable care and then it will develop in all its characteristic symmetry and loveliness and will not be crowded into weakness and deformity.

There are many species of tropical plants in the world still rare or unknown on this Island; some of them are obtainable from our government Experiment Station. They should be tried in different parts of the Island. The early Spanish colonists brought to Porto Rico, from the gardens of the Old World, not only a large proportion of her most valuable agricultural plants and fruit trees, but also a great variety of the choice shrubs, vines and flowering plants; in like manner should her people of today add to the comfort and delight of the generations to come by contributing some touches of their own time to the poet's picture of "The Garden of America."

The Livestock Industry

By Jaime Bagué, D.V.Sc.,

President, Board of Examiners, Veterinary Medicine. Chief, Division of Zootechnics, Insular Experiment Station.

The study of modern agriculture involves a number of subjects so correlated that from the advancement of them all depends the progress and richness of the agricultural interests of this island. One of those branches is the raising of livestock. It is a blunder to en-

courage livestock raising by itself. It is high time that our farmers should understand that agriculture is the combined action of raising crops and livestock. To repeat what Molina Serrano once said: "Crops without livestock and livestock with no crops is a chimera."

First Importations of Livestock: Twelve years after the discovery of the Island by Columbus in 1493, one of his captains, Yáñez, landed on it two herds of livestock; one of goats, the other of hogs. Yáñez decided to do this as a preliminary step in the colonization of the country; because he noticed, at the time of the discovery, the total absence of domestic animals. Years went by and the pigs brought by Yáñez adapted themselves so well to their new environment that they grew and multiplied with rapidity. When Ponce de León obtained royal permission to conquer Porto Rico he landed there in 1510, and imported from Santo Domingo, where they had been introduced from Spain, a few heads of cattle and horses. The two above mentioned importations are the foundation stock of the animal industry in this island.

The fertility of the soil coupled with the light climate, the cool and healthy waters of the brooks, and the exuberance of pastures were important factors in the development of a beautiful, strong and useful livestock. In 1534 the idea was conceived of importing stallions from Andalucía (descendants of Arabian horses) for a big remount station located in the vicinity of Jayuya. Porto Rico's horses were sold to the Spanish men-of-war that used to stop here on their way to the conquest of Peru. These boats were the pioneers in a trade that years after brought to her shores the ships of many nations to secure cattle for slaughter.

Development of the Livestock Industry: As time went by, the livestock industry partook of the energetic development given to the other branches of agriculture. According to Molina Serranos Memoirs on the Bovine Breeds of Porto Rico, (1882) the cattle of the Island had reached an extensive development. It is a known fact that the cows raised and selected by the Apontes, Berríos and Colons in the town of Yabucoa, and the work oxen produced by the Amys of Guayama were the best of the island. He further states that there were two distinct types of cattle: a small one that prevailed in the hills and a bigger one that roamed on the coastal plain. These types are still in existence. The stock

increased in number to such a degree that the island was able to export cattle, even after the American occupation, to England, Cuba and other foreign countries.

The marginal notes affixed by Mr. Jose J. Acosta to the Geographical, Civil and Natural History of the Island of San Juan Bautista de Puerto Rico by Fray Iñigo Abbad y Lasierre, show that the first steps taken to better the stock were made with the idea of increasing the size and stride of the oxen. With this purpose in view a number of bulls of the Buffalo breed were imported from Africa and their get were fine, strong and lively animals.

About 1870 Mr. Jorge Látimer, imported from the United States for his estate in Río Grande, one bull, a cow and two heifers of the Short-Horn breed. This small herd was famous for its milking qualities, but its blood was lost.

Side by side with the cattle the horse was developed. All of the southeastern portion of the island produced good-sized, well set up horses of quite bloodlike heads, feet and legs that went to decorate the stables of the rich: residents and foreign.

The Yabucoa Horses: In 1840 Mr. Ramón Aponte took to the fertile plains of Yabucoa two mares sired by an Arabian horse that was imported by a gentleman from Ponce. Mr. Aponte having a big farm where horses were selected, bred and well cared for. It was a question of pride for this gentleman-farmer to win the prizes offered by the towns of Caguas, San Juan etc. at their annual horse-fairs. The horse "El Manchado" is still remembered by the older generations; because he was as famous in his days as "Perla Fina" was in recent years. A big number of his colts were sold at one thousand dollars each; a thing unheard of, in those days. These stallions headed the fine studs of men like Marquis de las Claras in Arecibo. They also won for the farmers of Porto Rico the respect of the people of Venezuela, Cuba and Mexico which imported them, and consequently they made reputation for Yabucoa, the town of their origin.

Effect of the Development of the Sugar Industry: The year 1898 brought Old Glory

to Porto Rico and pretty soon it was followed by promoters from Wall Street. These men fostered and stimulated the growth of the sugar cane industry. The sudden rise in prices, the building of modern mills, and the demand for the product helped to increase the planting of sugar cane which had been, for years an established crop in the Island. A short perusal of the following exhibit shows the steady growth of the sugar industry and its effect upon the livestock population of the country.

The reader may easily imagine that this gradual diminution in animals and their products has caused an exorbitant rise in the commercial value of milk, cheese, etc. In the year 1875 milk was retailed at four cents per quart and cheese was sold at eight cents per pound. In 1921 milk was valued at twenty-five cents per quart. Today cheese is worth sixty cents per pound. The balance of milk used by the people is imported in condensed and evaporated form. Our total imports of canned milk reaching the sums of \$330,173 in 1917; \$551,331 in 1918; \$504,330 in 1919; \$634,047 in 1920 and \$834,375 in 1921, then dropping down to \$448,879 in 1922 after the drop in the sugar prices.

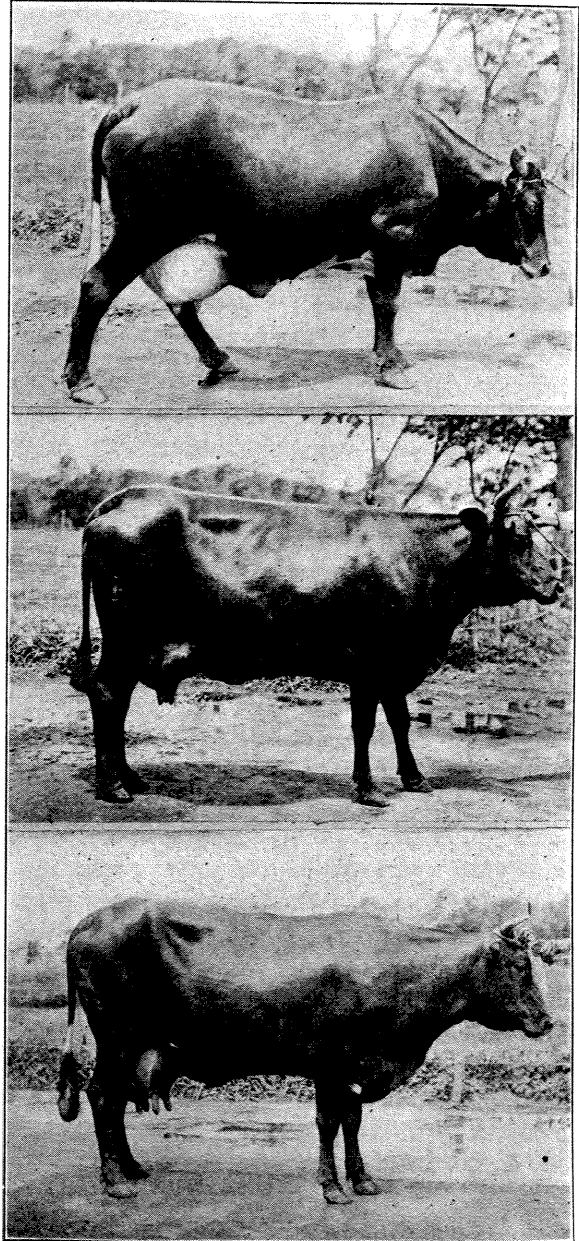
It is a known fact that every person ought to consume at least one quart of milk per day. The lack of vitamins in condensed milk is also an accepted truth. The statistics just examined are a positive proof that the inhabitants of Porto Rico are, in the point of milk consumption, far from the modern food standards.

Balanced Farming: The actual effect of such a condition on the agriculture of the island may be explained in a few lines. Balanced farming, that is, the keeping of a ratio between the number of animals and the size of crops on the farm, has been the long and cherished preaching of agricultural authorities. The wise farmer who keeps this idea in mind is always in a position to face all kinds of times and to help his less fortunate brother farmer. This points clearly to the fact that the farmer, for his own sake, must work hard to bring back to its old state of growth and prosperity the animal industry of Porto Rico.

It is not imperative to give up sugar-cane growing and to use these lands to keep cattle.

As a first step in securing better and more stock we must provide plenty of forage and for that purpose we ought to cultivate the hills where sugar cane cannot be grown to advantage.

A second step would be the separation of



VACA DE PURA SANGRE (ARRIBA), "SHORTHORN" MEDIA SANGRE Y "SHORTHORN" PURA SANGRE, DE LA VAQUERÍA DE DON R. LA COSTA.

MILCH AND MEAT CATTLE. (TOP) THOROUGHBRED NATIVE, 20 QUARTS, HALF-BREED SHORTHORN, 15 QUARTS, AND PURE SHORTHORN 20 QUARTS PER DAY.

the stock into its main types in order to give the proper care and feeding to each particular one. The importation of pure-bred sires in order to bring about a systematic grading up of the stock is another important step to take. If together with this we succeed in increasing the knowledge of veterinary science and animal husbandry among the farmers the results will be astonishing; because the physical constitution of the stock that is left us is excellent and the only epizootic diseases that prevail among it are anthrax or hog cholera.

Recent Importations of Pure-bred Animals:

The well-to-do farmer is awakening to these facts and a number of pure-bred animals are imported every year. In this respect the work of Biascoechea, Fonalledas, La Costa, Mongil, Nevares, Pizá, Ruiz Soler, Quintero, Usera, Vahamonde, Fajardo Sugar Co. and Aguirre

Agriculture, which recently imported a horse and a mare of pure Morgan blood.

Cattle Tick Eradication: The most serious drawback to the improvement of our stock, especially cattle, is the tick. This parasite is found all over the island and it is a serious menace; because it is the carrier of the Texas fever plasmodium, which is fatal to cattle, and especially to pure-bred cows and bulls. From our annual report covering the activities of the Division of Zootechnics of the Insular Experiment Station for the fiscal year 1919-20, we copy the following paragraphs:

Cattle Tick Eradication

"History.—In November, 1918, in the Agricultural Congress held at Mayaguez under the auspices of the College of Agriculture, the Food Commission, the Experi-

TABLE SHOWING THE DECREASE OF THE LIVESTOCK INDUSTRY IN PORTO RICO

Census	Horses	Pigs	Milch Cows	Pasture lands (acres)	Sugar cane lands (acres)	Milk sold (gallons)	Cheese manufactured (pounds)	Inhabitants
1776*	23,195		77,384		3,156			80,000
1830	25,760	25,087	42,500		14,803			
1899	58,664	66,180	73,372	1,127,686	53,758			953,243
1910	55,225	103,041	62,890	15,826	145,433	13,096,132	106,061	1,118,012
1920	46,922	98,760	61,864	20,409	227,815	7,613,001	62,522	1,297,772

(*) In 1776 Abbad grouped the mules pigs, goats and lambs under one heading, making a total of 49,050 animals.

Centrale deserves praise and stimulus. The above-mentioned parties have imported individuals of the Holstein, Short-Horn, Jersey, Guernsey and Ayrshire breeds. The Aguirre Centrale has imported recently Buffalo cattle and a pure-bred Arabian stallion.

Some help is coming from official quarters. The United States Experiment Station, the College of Agriculture and the Department of Agriculture of the Government of Porto Rico are actively engaged in solving this agricultural problem. The United States Experiment Station has done a splendid work in the breeding and top-crossing of Guernsey cattle with native stock. A similar success has been attained, with the Jerseys, by the College of

ment Station and the Department of Agriculture and Labor, the writer addressed the audience on the subject of Tick Eradication. Previous to this talk we had opportunity to work out practical tests in the vat constructed by the Entomology Division of the Federal Station at Mayaguez. The talk was followed by a practical demonstration, which closed the proceedings of the congress.

"During the ensuing summer the Food Commission, thru its Division of Agriculture, engaged the services of the writer to deliver a series of lectures throughout the island. Every town was visited and 3,000 farmers attended the lectures. It was

planned to work the idea in co-operation; but it failed, and the local boards appointed did not take care of the work.

"The next step was taken when the Legislature placed \$15,000 on the budget of the Insular Experiment Station of the Department of Agriculture and Labor for the purpose of conducting a campaign against the cattle tick.

"Work of the Insular Experiment Station.—In July, 1919, the Division of Zootechnics of the Insular Experiment Station was established and the writer was placed in charge.

"After a survey of the whole field it was found that, due to the work done by the agents of the Food Commission, there were twenty-two vats working in the Island, four of them being in the town of Corozal.

"The first step taken was to write Circular No. 18 in popular language and for free distribution. This circular is illustrated and embodies information on the habits of the cattle tick, the methods of eradication and the construction of vats.

"Taking into consideration the fact that chemicals were needed and must be secured cheaply, we started to stimulate the introduction of the particular chemicals necessary for this work. With this purpose in view, we called on some merchants who deal in fertilizers and farmers' supplies and to them we explained the idea. At the present time it is an easy matter to obtain the materials when needed.

"As soon as the preliminary steps were over we started to call on the farmers and stock men of the Island. During seven months we visited thirty-six towns and travelled over four thousand kilometers. This work brought us in contact with the people and we were able to find out their objections to the matter and to fight them on the spot.

"As a result of these personal talks and the concerted efforts of the sub-inspectors of agriculture, we were able to raise the number of vats built to forty-three.

"In order to keep in contact with the



TANQUE DE INMERSIÓN PARA MATAR LAS GARRAPATAS.
DIPPING VAT FOR ERADICATION OF CATTLE TICK.

farmers we prepared postal-cards and a set of books in which to keep statistics of the animals dipped each month in each municipality. In these cards the owners give the number of head of cattle under treatment and they are placed on our files. On that account we are able to state that from July 1st, 1919, to February 29th, 1920, 17,409 head of cattle were under treatment.

"Periodically the people who owned vats and those who were interested in the matter received mimeographed copies of the latest reports of the results obtained by the more progressive farmers.

"On November 18, 1919, the first Government-owned vat was opened for business in the grounds of the Insular Experiment Station at Río Piedras. On the 6th of February another public vat was ready for work at Vieques.

"These public vats had such a good effect on the campaign that it was recommended that the construction of a number of them be undertaken to be used as demonstration vats in every district. This idea was approved and acted upon.

"The publicity end of the campaign was not overlooked. Small items were sent to the papers for publication, and a regular illustrated advertisement appeared in the daily press for a number of weeks.

"On February 29th, by order of the Commissioner of Agriculture, the work was turned over to Dr. Varas of the Bureau of Agriculture."

At the time this is written the tick eradication work is still going on under the supervision of that Bureau. The Legislature has passed a law to make the construction of vats compulsory for every farmer owning one hundred or more head of cattle. At present there is a total of 135 vats, of which 106 are private and 29 government owned. The vats are located in fifty-two out of the seventy-

five municipalities that make up the whole Island.

Importations of the Insular Experiment Station: With an appropriation voted by the Legislature, hogs of the Berkshire, Red Duroc Jersey and Tamworth breeds and two bucks and a few goats of the Toggenburg breed were imported by the Insular Experiment Station in February, 1920. Their offsprings are sold at very low prices so as to make them available to the farmers throughout the Island. The Station is ready for an importation of fifteen heifers of the Guernsey breed to be used as foundation stock for a dairy. The Department of Agriculture intends to establish breeding stations all over the Island so that all sections may be benefited by this work.

As soon as the farmer can secure better and more livestock the island will be in a position to develop such industries as butter-making, cheese-making, and the manufacture of pork products. In the meanwhile let us follow Bakewell's advice: Breed livestock, for beauty of form and utility of function.

New Industries

For Which Awaits a Profitable Field

By **Rafael Fernández García, B.Sc.**,

Industrial Chemist, Consulting Chemist, "Sociedad Agrícola Balseiro y Giorgetti."

The sugar industry in Porto Rico completely dominates the agricultural and industrial life of the island. Of the total acreage under cultivation 34.5% is devoted to sugar cane; 49.8% of the aggregate value of agricultural products is sugar cane, and 25% of the total number of workers in the island earn their living in that industry, not counting the thousands who work in enterprises which turn out products consumed by it. Of the total capital invested in manufacturing industries, 78.8% is in sugar factories, and, lastly, during the years 1919, 1920 and 1922 the exports of sugar and molasses amounted, respectively, to 62.4%, 66.4%, and 62.3% of the aggregate exports of the island for those years.

Sugar First, Coffee and Tobacco Next. Coffee and tobacco combined—the two Porto

Rican products ranking next to sugar in importance—are equal to sugar cane only as regards the acreage under cultivation, for, in other respects, even though considered together, they can not rival with sugar, the total capital invested in the industry they represent amounting to less than one-fifth of the corresponding amount invested in sugar, and the value of the exportations of the latter being double that of the former products combined.

Disadvantages of One Predominating Single Industry. It is thus seen that in Porto Rico a great single industry predominates and, further, one whose outgoing trade depends almost exclusively upon one single product. The result being that the periodical financial crisis suffered by the island caused, at times by overstocked markets, as in 1920, by the threat

of tariff changes, as in 1912, or by ravages of plant disease, as was the case in 1877, come from the fact that the island depends almost entirely upon one sole industry—sugar.

Porto Rico, an Agricultural Island. Notwithstanding the fact that the island has a completely developed manufacturing sugar industry except in its refining, and many cigar and cigarette manufacturing establishments, Porto Rico is essentially an agricultural island, for the agricultural phase of these industries is the one which employs the largest amount of capital and labor. Coffee, her next product of importance, is exclusively of an agricultural character. In this connection it should be noted that all these industries make but periodical demands upon labor, the result being that during inactive periods the workers find themselves without employment. This is a decided disadvantage for Porto Rico which is so densely populated (378.4 inhabitants per square mile), and with a population per square mile smaller only than that of England, Belgium and Holland, great manufacturing countries owning besides large colonies where their surplus population can find employment.

Therefore, Porto Rico is in need of more manufacturing industries (the author will use hereafter the word "industry" in this restricted sense), without diminishing the cane, coffee and tobacco cultivation, and in this manner first she will be able to diminish the number of periodical crises by increasing the variety of the export articles and also by producing many that now have to be imported; and, second, to help provide permanent work for her surplus population.

The Fuel Problem. The fuel problem of the island deserves careful attention as accurate stock of its available sources of energy with a view to producing her own fuel, has never been taken, due to the fact that the only industry which uses power on a large scale, the sugar industry, produces its own fuel—the bagasse, or pulp from the ground cane.

The island's lignite and peat deposits are unknown but a considerable quantity, especially of the latter, could be extracted (this being in itself a new and profitable industry) and used through simple drying and "Briquet-

ting" processes, as it was done in Germany years ago and recently in the United States, in places where the production of coal or oil is quite expensive.

Its Solution. But the solution of the problem is not the one above suggested, but lies in the further development of the island's water power, the streams with their numerous waterfalls, not having been properly studied as yet, and in the artificial falls which it would be easy to build for the production of electric power.

There are approximately 1,300 streams in the island, including rivers and "quebradas" or brooks, whose capacity varies with the seasons. The larger streams carrying at all seasons large volumes of water, they having the advantage of a rather steady rainfall, and during the so-called rainy season, the overflowing of the larger streams varies from 10,000 to 20,000 cubic feet of water per second. According to H. M. Wilson (U. S. Geological Survey No. 32), the rivers on the northern and western sections of the island are the longest, measuring from 25 to 40 miles and discharge the largest volume of water, at a minimum rate varying from 250 to 1,500 cubic feet per second for the largest streams. The length and volume of the southern and eastern rivers are less, their length varies from 5 to 15 miles, and their minimum discharge of water from 50 to 100 cubic feet per second, but on the other hand the falls of these latter streams are larger.

It should also be noted that these streams descend from 1,000 to 2,000 feet in a distance of from 3 to 5 miles passing through valleys and between banks of impermeable clay, especially on the north where the building of a dam for the storage of flood waters and the formation of an artificial waterfall would seem easy and comparatively cheap.

Kinds of Industries That Can Be Developed. The industries that can be developed may be grouped into four great classes—(1) Industries based on density of population and consequently abundance of labor; (2) industries based on raw materials which are now exported in their unmanufactured state; (3) industries based on raw materials which may be advantageously imported or agricultural prod-

ucts of easy growth in the island; (4) industries based on raw materials which exist but have not yet been utilized or, if at all, improperly utilized.

Industries Based on Density of Population.

Owing to the abundance of labor, industries in which manual work is the principal factor and raw material of secondary importance, may be easily developed. The average daily wages for 10 to 12 hours of work of the "peón" or laborer fluctuating between sixty cents and one dollar and a half, the corresponding wages for skilled labor being from one to two dollars a day. These figures represent the wages for men. As to women the figures are lower. Child labor is regulated by law, as in all parts of the world, and minors may be employed at certain times under special conditions and only in some industries.

Ready-made Clothing and Needle Work.

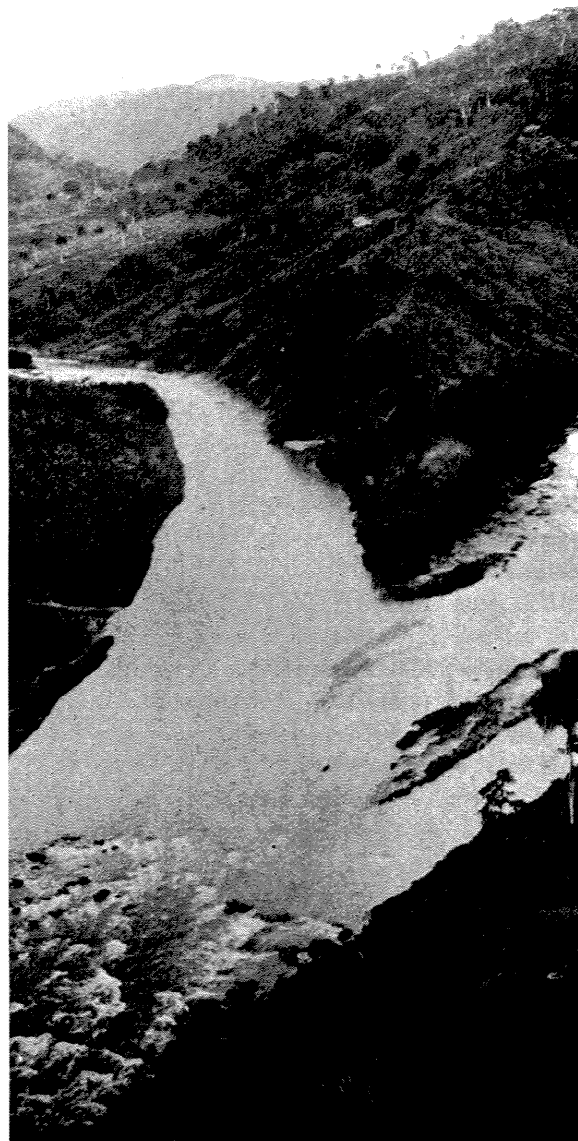
Among the industries that may be developed on the above stated basis is that of clothing manufacture and needle work, the raw material for which (it being a secondary factor) may be imported at small cost. During the last three years the ladies' blouse or waist manufacturing industry as a hand process has enormously developed, and today thousands of these garments made in Porto Rico are sold in the larger stores of the United States. The Department of Education is now training a large number of women in this work, thus increasing the number of workers available for this industry.

The great number of "middlemen" employed in this industry, however, makes the latter hardly a profitable enterprise at present for the workers. A cooperative producing association would liberate them from this handicap and, incidentally, would give the consumer a more uniform and better product.

Toys. The production of wooden toys may be developed along lines similar to the manufacture of waists and other garments, it being in this manner that the industry thrives in Germany. The recent exhibition at the "Baldorioty School," which is described in another article in this book, being a splendid effort in this connection.

Industries Based on Raw Materials Exported

in Their Unmanufactured State. The island produces annually about twenty-four million coconuts which are sent to the United States and to foreign countries to be made into oil,



"LOS DOS BRAZOS", CERCA DE ARECIBO.
THE JOINING OF THE WATERS: ARECIBO RIVER RAPIDS.

fats, sweets, etc., products that the island is compelled to import under numerous trademarks and labels.

The so-called "vegetable fats" that the island consumes in great quantities also are but hydrogenated products of cotton and coconut oils.

The demand is so great in the United States, in fact, for the better qualities of coconut oil for the production of "oleomargarine" and vegetable fats for the production of crackers, that its price has become prohibitive for the manufacture of soaps.

A plant for the extraction of oil from the coconut instead of exporting the nut could be operated by one of the sugar mills on the northern section of the island, during the period in which the mill is inactive, and the dried pulp (or "cachipa"), the residue, thus obtained, mixed with molasses could be used as hog feed and this would facilitate hog raising on a large scale.

From the coconut shell can be obtained, as is done in other countries from wood, distilled products such as acetic acid, acetone, etc. Here it is interesting to note how because of its great absorbent properties, the charcoal obtained from the burning of the coconut shell was used during the war in gas masks. Cannot other uses for it be found? Could it not be economically used in the sugar industry, as a substitute for animal charcoal or bone-black?

Another possible industry based on the coconut would be the manufacturing of coconut balls for sale on a large scale to candy manufacturers in the United States for use in the making of the many lines of candy they produce.

Industries Based on Raw Materials Which May Be Advantageously Imported or Grown in Porto Rico. Raw hides are and probably will always be on the free list of the American tariff, as they are required by large manufacturing interests in the New England states. This condition could be made profitable for Porto Rico, if the Island should stop exporting hides and instead, import them from Venezuela, which is so near, and then tan them. Mangrove, so largely needed in tanning, and now so little used on the island being cheaply obtainable.

Shoes. There is in Porto Rico an extraordinary shoe market, which does not figure now in the island's import trade. From six to seven hundred thousand inhabitants of the island today wear no shoes on account of the expenses

their procuring entails. A strong, ordinary shoe that could be purchased at a dollar or a dollar and a half a pair would find a ready market here. This would not only amount to a real profit for its originators and supply many with employment, but it would accomplish a needed charitable work, as it would free thousands of Porto Rican laborers from the continuous ravages that the hook-worm disease makes on them. It is not an impossible task, either, when it is realized the advantage brought by the production of a standardized article on a large scale.

Due to the lower wages prevailing in Porto Rico and to the difference in freight rates, of raw materials, her best class shoes also could find a ready market in the United States.

Tapioca. The yucca-plant starch, which has been recognized by noted chemical experts from the great textile establishments as the best starch for laundry purposes, is made in Porto Rico in negligible quantities, by old and inefficient methods.

In Cuba there are several manufacturing plants for the production of tapioca on a large scale, the manufacture of which costs less than half a cent per pound, according to machine efficiency. There is to be found today on the market, small, efficient machinery for the production of yucca-plant starch which can be properly handled by landowners of small crops.

In this connection, it should be noted that the yucca-plant does not require much care, as it grows quite well on soft, sandy soils, which might not be useful for other more profitable products, some of the best varieties of this plant rendering an amount varying from 25% to 35% of starch and a production fluctuating from three to five tons of roots per acre.

Manufacture of Bags. The great cheapness of labor has kept for India the monopoly in the production of jute, but not in the manufacture of jute bags, for Dundee, Scotland, has been the center of the jute manufacturing industry since the middle of the nineteenth century, when the first experiments in jute weaving by machine were made there. In and about Calcutta this fiber is also woven at the present time.

"Burlap" or woven jute, in widths of from

22½ to 76 inches is imported into the United States at the rate of from 75,000,000 to 100,000,000 yards a month of which Porto Rico consumes quite an appreciable quantity in her sugar industry, although most of the bags are imported from foreign countries. Porto Rico could import the burlap it uses, even if it could not at present manufacture the cloth because of the expense involved, and make the bags by machine, employing women for this work.

In this connection, too, attention should be called to the fact that some of Porto Rico's malvaceous weeds yield a fibre equal to jute for bag making.

Industries Based on Raw Materials Which Are Not Utilized at Present. Fruit Juice. The manufacture of nonalcoholic beverages from fruit juice is an industry which would strengthen the development of the fruit industry.

Most of the fruit juices or extracts are of easy preservation when sealed containers are used, after sterilization at moderate temperatures of 75 to 80 degrees centigrade, all fruit juices being somewhat sour. The juice of various fruits requires various treatments, for some simple sterilization or carbonated treatment will suffice, while others require concentration by freezing, and all may be preserved from two to three months or more if kept in storage at a low temperature. These juices so prepared find great acceptance in American markets. The machinery and capital required represent a comparatively small investment. The freight on bottles to be used as containers which have to be imported could be saved either by manufacturing the bottles here or by exporting the juice in demijohns to be bottled where sold.

Utilization of Final Molasses. Porto Rico produces annually about 100,000 tons of final molasses (88 Brix) of which part is used for the production of alcohol, part for fuel and the major portion for export, but the price is so low that for some "centrales" the disposal of their final molasses is somewhat troublesome as it can not be got rid of by throwing it into surface streams, this being prohibited by law.

One ton of final molasses has the same heating value as a barrel of petroleum, and an

equivalent money value of about two dollars, but its use as a fuel is very difficult, the recovery of potash from the ashes being possible only when furnaces of special construction are used.

Now, a ton of molasses produces 65 gallons of alcohol (95%) approximately, or 60 gallons of a mixture of equal parts by weight of alcohol and ether which can be used as fuel in motors of internal combustion. This fuel is now being used with splendid results in Natal, Australia and Hawaii. In the last named country the production costs about 8 cents a gallon. A factory with a capacity of a thousand gallons a day which would cost approximately \$35,000, could produce this fuel at an average cost of from 10 to 12 cents a gallon.

Besides fuel as above stated, there could be obtained from a ton of molasses, as a by-product, about 200 pounds of ashes containing from 25% to 30% of potash (K₂O) in carbonate form with a value of from \$1.25 to \$1.50 a hundred pounds.

By developing this industry Porto Rico could be freed from foreign monopolies, as it would produce its own fuel (during 1922 she imported gasoline to the amount of 4,087,919 gallons from the United States alone at a cost of \$1,165,533), and would also enable her to produce her own potash.

The mixture of alcohol and gasoline which is now being manufactured and used in Porto Rico is more expensive than that of the alcohol and ether above mentioned, for besides the use of gasoline (an imported product) which the former requires, the gasoline used must have a low degree of volatilization which means the best and most expensive grade, in order to obtain a mixture which will burn well.

Utilization of the Bagasse. The sugar industry utilizes the bagasse as a fuel. Its value as such is equal to that of molasses, or about \$2.00 a ton. The use of bagasse as a raw material for the manufacture of paper has always found as an obstacle the separation of certain fibers, the presence of which gives paper non-desirable quality. But this difficulty has been obviated through the use of strainers.

Arthur D. Little, Inc., owners of the famous American laboratory for industrial chemical

researches, have stated in a comprehensive report to the Hawaiian Planters' Association:

"As the result of investigations made with reference to the possibility of making paper from Hawaiian bagasse it is our opinion that technically there are no obstacles that can not be easily overcome," and further: "From the standpoint of economy it is our opinion that a pulp and paper factory properly designed and with a capacity of 30 tons would represent under normal conditions an attractive commercial investment."

The bagasse fiber makes a good paper for books but not for wraps, as formerly believed, the primary consideration in the latter use being strength.

Considered as a raw material for paper the bagasse is three times cheaper than any other.

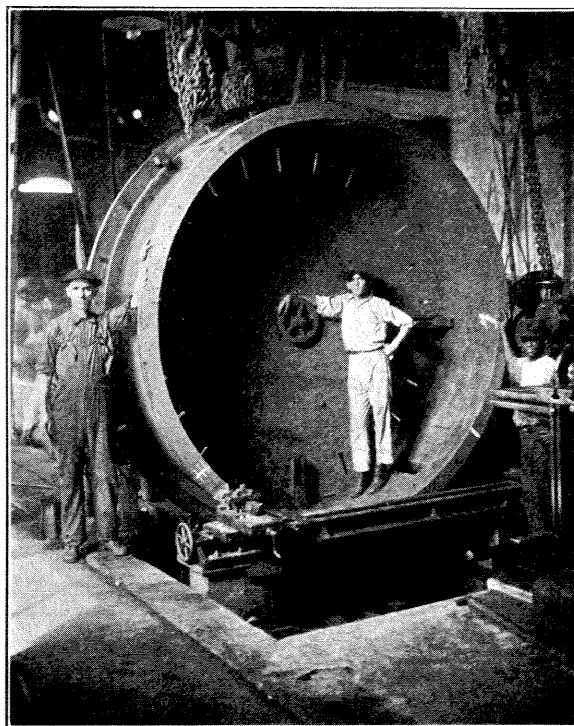
The use of bagasse as raw material for wall-board for interior wood-work in buildings has been demonstrated by a recent American patent and there is now in process of erection a factory for this purpose in the neighborhood of New Orleans with a capital of \$500,000. Through this process from one ton of bagasse there may be obtained 3,000 square feet of wall board half an inch thick. With timber at \$35 a thousand feet this proposed use of bagasse would seem to deserve careful consideration.

These two industries—the utilization of molasses for the production of fuel for internal combustion motors, and the use of bagasse for the manufacture of paper and wall-board are very worthy of the attention of the sugar growers, as they would tend to strengthen the sugar industry.

Coconut Fiber. Several factories have been established for the extraction of fiber from the outside shell of the coconut for export, but all have had a precarious life of short duration. The probable cause of these failures, aside from the deficiency of the machinery which breaks a considerable quantity of long fibre, is the limited field for the industry itself. The extreme specialization may be undertaken with profit only in the case of basic industries. Why not convert into finished articles this semi-raw material exported by these factories? This fiber can be availed of for the manufacture of

floor mats and similar articles thus utilizing what is largely at present a waste product.

Other Industries. Besides the raw materials already described there are others, such as fish (Spanish mackerel, herring, sardines, etc.,



LAS FUNDICIONES DE LA ISLA LLENAN EN GRAN PARTE LAS NECESIDADES DE LOS CENTRALISTAS.

A LARGE CASTING MADE IN ONE OF THE FOUNDRIES OF THE ISLAND.

for instance), vegetables and fruit, the packing of which if properly done, would constitute new and profitable industries.

Cement. The cement industry would require careful and detailed study of production costs, for foreign competition in this line is very great, the latter having to its advantage the low price of the raw material it uses. Limestone and clay are abundant in Porto Rico but not so in the case of lime sulphate. One of the principal factors in the manufacture of cement is the fuel used for heating.

Bottles. The local consumption of flasks and bottles of all kinds would seem to justify the erection of a bottle factory after a careful study of costs, for as in the case of the manufacture of cement, fuel is a very important factor.

A minute survey of the island's silica and lime carbonate resources would seem to be needed in this connection as the best grades of bottles require these substances free from all iron oxides. A substantial amount of soda and potash carbonates would also be needed, the potash carbonate being obtainable from molasses. In Europe the unrefined molasses obtained from beets is used for the lower grade bottles.

Soaps. Several attempts have been made on the island to establish a factory for the manufacture of soap, but these attempts have always failed. This is due partly to the lack of capital on the part of the promoters and partly to the poor quality of the raw material available. The fact that the Twitchell process for the treatment of the raw material can not be used, there being no local market for glycerine, is also a difficulty to be reckoned with. When a local industry for the manufacture of coconut oil has been established, the soap industry will be in a position to thrive.

All these industries, shortly after their establishment, would give rise to secondary industries for the manufacture of substances and implements such as caustic soda and potash, sodium carbonate, cans, containers and pasteboard boxes of all kinds and sizes.

Promotion of New Industries. As Porto Rico

has no control over custom tariffs for the protection of rising industries, it is necessary to look for other means, the necessity for creating new sources of revenues in the interest of the island's welfare being quite apparent.

First of all, it is imperative that a careful study of the possibilities of her most promising natural water-falls (and also of the artificial ones now in use) be made by one of the Departments of the Insular Government. As collateral to this work, it is also necessary that a study be made of the lignite and peat deposits to determine their availability as sources for fuel.

It would also seem advisable to create a Bureau of Industries under the Department of Agriculture and Labor for all the raw materials on which these new industries can be based are of vegetable origin, the Bureau of Labor being also a part of this Department, this bureau being devoted to the study of applicable industries and the methods used in them that seem best adapted to conditions in the island, these surveys or studies to be used by our business men in connection with the promotion of companies or corporations of low priced stock (\$10 to \$25 a share) the companies to be operated under the supervision of the Bureau itself.

