VIII

AGRICULTURE

ECONOMIC PROBLEMS OF PORTO RICAN AGRICULTURE—AGRICULTURAL EXPERIMENT STATIONS—SOILS AND FERTILIZERS—PLANT INTRODUCTIONS—PUBLIC IRRIGATION SERVICE—ISABELA IRRIGATION PROJECT.

The Economic Problems of Porto Rican Agriculture

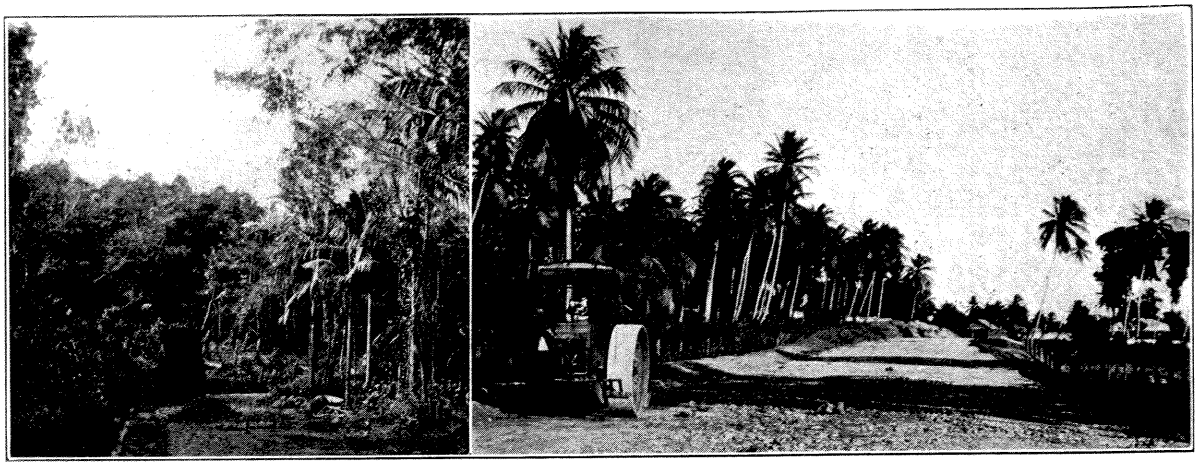
By Franklin Sumner Earle, M.Sc.,

Expert in Cane Varieties. Consulting Agriculturist, Aguirre Sugar Co.
President, Association of Sugar Technologists of Porto Rico.

Cause of Economic Problems: At their base all Porto Rico's problems are economic resulting from her crowded population and lack of sufficiently diversified basic industries. The three principal agricultural crops, sugar cane, tobacco and coffee are all seasonal in their demand for labor and each is confined to certain rather closely limited soil areas. While much can doubtless be done to increase production in each of these industries, the real problem is to find profitable employment for the working population during a greater part of the year, while at the same time bringing a much larger area of the lands of the islands into really profitable production. According to the data recently published by the Insular Department of Agriculture almost a million acres of the lands of Porto Rico are classed as pastures, while nearly a quarter of a million more are classed as brush and timber lands. Unfortunately only a comparatively small part of either of these great areas is at present giving a production that can be considered profitable from any point of view.

A considerable proportion of these lands are held in comparatively small tracts and the individual initiative of these small land owners has not been sufficient to overcome the difficulties of properly exploiting them. These difficulties are of various kinds. One of the most universal being lack of sufficient transportation facilities. The Insular Government is doing notably good work in opening up and maintaining a fine network of automobile roads which reach into all of the principal districts of the island, and which have already done much to stimulate production, particularly of local food stuffs. But more attention must be given to improve neighborhood roads so that products can be brought to these main routes from the remoter farms of the hill country. This question of roads is primarily a Government problem, still there are many localities where a little united effort on the part of local property holders and renters, would do much to improve present conditions. Co-operation among the small farmers of the island in constructing feeder roads is really one of the principal factors of better transportation.

Reforesting: On that which we may now consider as waste lands, a part are too steep and broken to be suited for general cultivation, but practically all can be used for tree planting, and should be reforested. This too has been considered as a job for the Government and as being beyond the means of the small land owner. This view is a mistake, as with the present scarcity of fuel, fence posts and other timber products, the making of small timber plantings in the highest of the hill lands, would be more profitable to the



CARRETERAS EN CONSTRUCCIÓN.—TRYING TO MEET THE NEEDS OF A GREATER PORTO RICO.

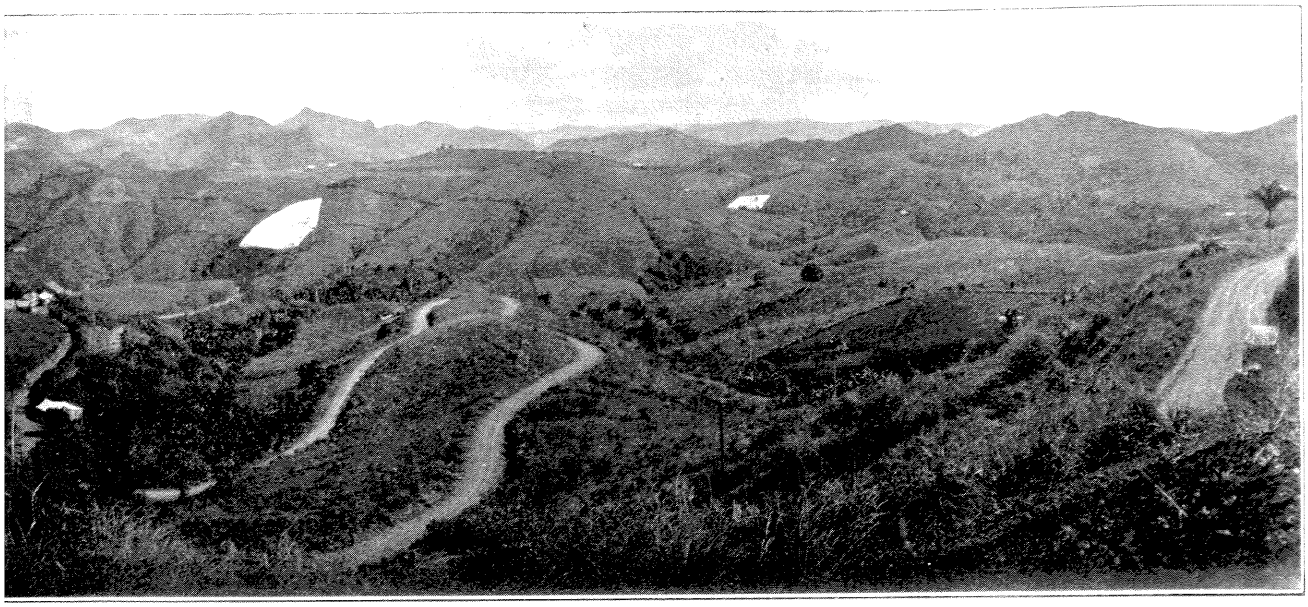
greater attention should be given to a home grown meat supply, for the small farmer—particularly hogs, goats and poultry. There is a well established cattle industry, mostly in strong hands, which provides a fairly adequate beef supply, but there is no possible justification for the heavy annual importation of various hog products, as with the great number of cheap crops for hog feed that can be grown, they can be produced here cheaper than in the Western Corn Belt, from which now they mostly come. In the States hogs have always been the principal money crop of the small farmer, and the same should be true here where sweet potatoes, peanuts and cowpeas (Frijoles) can be so readily grown in all parts, and can be pastured down with no expense for harvesting or housing.

Vegetables and Fruits: Besides the greatly increased planting of the minor food crops for local consumption, that would come with a reasonably efficient marketing system, a large export business could easily be developed with several of them. Our yautías under the name of Dasheen are now being extensively planted in Florida, and are being accepted in the northern markets, and sweet potatoes and onions can be sold in New York in practically unlimited quantities.

In fact, now that refrigerator steamship transportation is available, there is nothing to hinder the export of a consderable quantity of the more perishable winter vegetables, including tomatoes, peppers, egg plant, lima and snap beans.

Here again the individual farmer is hampered from lack of knowledge as to cultural and marketing methods. Co-operation among the growers and with the commercial interests will be necessary to develop any of these industries. The shipment of fresh vegetables is of course, closely allied to the fruit business which has long been established here in limited districts along the North coast convenient to transportation. The fruit business can be greatly extended on the cheaper and better adapted lands of the interior than those on which it is now established as soon as better feeder roads are constructed.

It is doubtful if equally good oranges can be grown as cheaply anywhere else in the world as in the red land coffee districts of Porto Rico. The quality is equal to that of either Florida or California while the cost of production is many times less. The planting of extensive orchards of Valencia oranges in those parts of hill country now reached by good roads represents a real economic opportunity. It is however a very specialized business and will only be successful in the hands of those who know it thoroughly. Large quantities of the so-called "wild oranges" are now annually shipped from these hills, usually with very heavy losses from decay in transit. This has been caused by rough handling, bad packing, and poorly ventilated



ROSAS.—PASTURE LANDS THAT WOULD MAKE FINE SITES FOR CITRUS FRUIT GROVES.

ships, and it is not due to any defective quality of the fruit. Those losses could all be avoided by proper management.

The Canning of Fruits and Vegetables: The canning of fruits and vegetables is an industry that is slowly gaining ground in Porto Rico. It should be considerably extended not only because it furnishes a market for grades and sizes that can not be shipped profitably in the fresh state, but because it furnishes additional labor for the surplus population and also gives an increased home market for locally produced sugar. Such industries should be stimulated in every possible way.

Vegetable Oils: Another industry of this same useful class could be easily developed in the production of vegetable oils. Peanuts and sessame (ajonjolí) can be grown abundantly on the white sand areas of the North coast that are now but little used, and also on the dry red lands of the Isabela district. Some one of the North Coast Sugar factories should install an oil mill which could be run before the sugar crop begins, so that it could utilize the same boilers and power plant. Both of these crops yield a table oil that could replace in our local markets the olive oil now so largely imported.

Fibers, Rope and Bag Making: Fibers for rope and bag making can easily be grown on much of what now is waste land. Sisal has been planted in a small way on the hills of the South Coast but the climate is a little too dry there for its best development. It would thrive better on the limestone hills of the North Coast which at present are yielding very little of value. Some of our common Malvaceous weeds yield a fiber that is fully equal to Indian jute for bag making. If Porto Rico should produce her own sugar bags it would certainly mark real economic progress.

Co-operation of Banking and Commercial Interests: These are only a few of the many possibilities for improving economic conditions in Porto Rico, and as will be readily seen none of them can be accomplished by the unaided effort of the individual farmer. They all require co-operation among the producers, the active aid of Government agencies and of the commercial banking interests. The Government is making an earnest effort to do its part. And it now remains for the banking and commercial interests to clearly realize that their prosperity depends on aiding the building up, by all possible means, of the buying power of their customers. When this is done a new day will dawn for Porto Rico.

Agricultural Experiment Stations

By Edmundo D. Colón, M.Sc.,

Formerly Member of the Faculty of Louisiana State University and of the College of Agriculture and Mechanical Arts of the University of Porto Rico. Ex-Director, Insular Experiment Station. Agronomist, "Sociedad Agrícola Balseiro y Giorgetti."

THE TOA GRANGE

Its Foundation and Aims: If an agricultural experiment station is, in essence, an institution for the purpose of advancing agricultural progress by means of practical example, in whatever form, then Porto Rico had its first experimental centre in the first quarter of the XVI. century, when, by order of King Ferdinand, the Catholic, an agricultural grange was established on the banks of the Toa or Plata River, in the vicinity of the place still called "The Catholic Monarchs." In it, and supported by revenues of the Crown, experimental plantations were made by expert Spanish laborers, cultivating fruits, grains, garden vegetables and other useful plants brought from Spain and the Canary Islands and acclimated in the Island, thus giving example and practical instruction to the colonists. (See Brau's History of P. R.) A few months before the death of the sovereign in 1516, the installation of another similar grange in San Germán was solicited, but neither the concession of this one was realized, nor did the Toa estate, suffering the loss of royal support, long survive.

The Legacy of the Early Colonists: The grange closed its work but, as the product of the colonizing genius which inspired it, the Indian of Porto Rico saw livestock of all kinds, the cocoanut palm and the peach tree growing upon his soil.

The historians Brau and Coll y Toste name among the species probably imported during this period cattle, horses, asses, sheep, goats and hogs; wheat, barley and the grape, a variety of garden vegetables and other garden plants; rice and sugar cane, lemons, limes, grape fruit, sweet and sour oranges, the tamarind, fig, olive, peach, apricot, cherry apples, pomegranates, pears, walnuts, chestnuts, the plantain, banana, yam, cocoanut palm, Spanish fowls and guineas. This labor of our ancestors was notable and should be remembered.

THE SPANISH AGRICULTURAL STATIONS

The Period of Gestation: A long interval elapsed between the sixteenth century with its eagerness for acclimitization and its model grange conducted by humble but expert laborers and the nineteenth century with its centres of agricultural investigations in the hands of professional agronomists similar to those whom we know today.

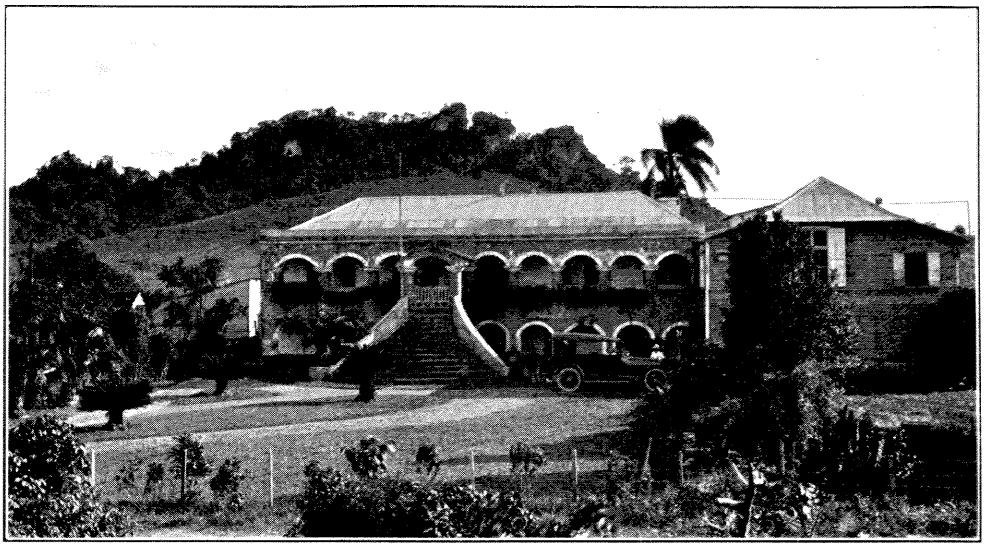
During the period were introduced diversified elements such as the Cassia fistula and cacao and coffee and in the commercial exploitation of the native woods and tobacco; concessions were granted, ports were provided, immigration was stimulated; Power and Ramírez establish our insular finances, the "Sociedad Económica de Amigos del País" (Economic Society of Friends of the Country) began its educational work, the earliest articles known in behalf of the agriculture of the Island appeared in the "Diario Económico," and the yields of sugar and forage increased with the introduction of Otaheite sugar cane and "malojilla" grass. Acosta writes his memorial, "The Questions of Laborers to Solve the Actual Land Problem of Porto Rico," then his "Elements of Theorical Agriculture as Applied to Tropical Cultivation," and later his annotations to the History of Abbad.

The government founded then three institutions which always mark the beginning of conscious agricultural support, namely, the Agricultural School, agricultural meetings and agricultural boards.

The Ateneo opened its doors, the Philotechnic School and the Civil Institute, Stahl, Gundlach and Dewitz studied the island's natural history. The first agricultural society arose in Ponce. Aguayo issued the book which instructs a generation of tobacco planters. The agricultural progress is all compiled, in a Fair, that of Ponce, and a memorial,

that of Abbad. Molina Serrano vigilantly called attention to the degeneration of the races of cattle. And finally, the "sugar cane disease" makes its sudden appearance in Mayagüez.

The Opportune Hour: At this opportune moment, and in the name of "Ponce Agricultural Society," of which he was the legal representative, Licentiate Antonio Alfaut y Baralt presented a petition, which proved fruitless, to the Spanish Overseas Ministry, that the "Law of Support" of 1876 should be made extensive to the Province of Porto Rico and establish in Ponce a Model Experimental Grange with its Agricultural Experiment Station. Later, with no better result, the municipal council of Cayey petitioned for the establishment of an experimental grange in that locality. Finally, after a petition calling for it made in 1886 by the province, two agricultural stations were created in Porto Rico. These were finally situated, one in Mayagüez in charge of the Agronomist don Guillermo Quintanilla, and the other in Río Piedras, in charge of the Agronomist, don Fernando López Tuero.



ANTIGUA CASA, ESTILO COLONIAL, DE LA HACIENDA SANTA ANA, PONCE.
THE LASTING HOME OF AN EARLY SETTLER.

Organization: The general rules by which these stations were administered formed a part of the royal decree which created them, stipulated both their aims and their obligations. These rules appeared in the "Official Gazette" of 1894 and in the "Review of Agriculture, Industry and Commerce" of 1888. In 1891 the same gazette published the tariff of analysis for public service. For lack of other means of circulation many of the quarterly, annual and special reports were printed in the "Gazette of Porto Rico" and a few in the newspapers and reviews of the time.

The above-mentioned reports were transmitted to the Overseas Ministry for its consideration and opinion and for that purpose the Agricultural Board of Consultation of the National Government was utilized. The annual budget for maintenance was scanty, being in 1894 and 1895 only $12,500 for both centres, $9,300 being for personal expenses and $3,200 for material. For a time both centres were in charge of the Diputación Provincial.

Its Work: To correctly appreciate the labor carried out by the Spanish Agricultural Stations in the seven years or thereabout during which their activity lasted it is necessary to bear in mind two considerations: the necessities of the farmer of that time and the state of agricultural science during the last quarter of the nineteenth century.

The total wealth of exact knowledge of insular natural history consisted in the works

of Ledrú, Martens, Grossourdy, Bryant, Sundevall, Peters, Dewitz, Bello Espinosa, Stahl, Gundlach, Sainte-Claire Deville and Vargas, all works of merit, but in the department of pure science.

The facts that the work of Liebig on agricultural chemistry did not appear until 1840 and the discovery of Hellriegel of the fixation of atmospheric nitrogen by leguminous plants until 1886, that no meritorious work on vegetable pathology appeared until that of Kuhns in 1858, that the practice of repression was not successful until 1883 with the grape vine in France, and finally that hardly thirty years have elapsed since the first investigations on the bacterial diseases of plants, are conditions that give an idea of the limitations to which the efforts of Lopez Tuero and Quintanilla had to be subject.

They alone had to begin, as they did, the study of the cultivated soil of the country, which had begun notably to fail on account of the long continued production of sugar cane, coffee and tobacco; the study of suitable fertilizers; of the sugar cane disease, which years before had begun its ravages in the fourth department of the Island; of the so-called "disease of the coffee tree" in Ciales and Adjuntas; of the varieties of sugar cane, introduced into the country to substitute the Otaheite white, which was "running out," of the causes of the poor yields in the sugar factories, estimated at from 7% to 8%; of the necessity of irrigation for sugar cane, of the use of the guanos of Porto Rico as fertilizers, the curing of tobacco; of the disposition of the fruits which were annually wasted in the country; of the agave (sisal), the sanseveria, the alfalfa, the clover and other plants, in an effort to suggest new resources to the narrowly diversified agriculture of the Island.

There were also other investigations of minor importance and several works in popularizing agricultural knowledge of which the authors were the directors of the two stations, and Stahl, Acosta, Baldorioty, Abbad, Asenjo, Gadea, Grivot, Grand-Court, McCormick, Molina Serrano, Umpierre, Sichar, Vendrell and Valle Atiles. This completes the humble but significant agricultural work up to the period of the new domination.

To that period, so poorly appreciated, the country owes the repudiation of the then prevailing administrative system which crushed out all agricultural initiative, the low-yielding Cavangerie sugar cane, which is still largely cultivated, the introduction of the Rayada and Crystallina canes, which still form the greater part of its crop, the exploitation of its guanos, the introduction of chemical fertilizers, the importation of pure breeds of dairy cattle and hogs, its first climatological records, free labor, and the implantation of the system of sugar centrals.

It has been necessary to keep in mind these works, to appreciate them and to improve upon them in the light of the discoveries of a later day.

THE FEDERAL EXPERIMENT STATION AT MAYAGUEZ, 1901-1922

Point of Departure: But unfortunately this recognition of the work of the Spanish stations did not take place, the men who were intrusted by the government of the United States with investigating the agricultural conditions of this island did not form a true idea of the activities in that field which had preceded the new government, some of the aspects of which we have just briefly reviewed.

Mr. Evans, of the Federal Department of Agriculture, expressed himself as follows in regard to those activities:

"It appears that during the old regime very little was done in the investigation of agricultural problems. A mutual society was formed in San Juan for the encouragement of agriculture which lasted some years. It had a head office in San Juan and other branch offices in each important town, but no permanent results were obtained by it. In 1864 an agricultural gathering was held in Ponce and another similar meeting was held in San Juan in 1882. These meetings were similar to the State or Country fairs held in the United States and they were held only in the years named.

"In 1889 the Spanish government established two experimental stations in the Island; one in Río Piedras, near San Juan, and the other

in Mayagüez, but after having cost the province considerable sums of money, both were closed apparently without having given results. They do not seem to have recorded their projects or their equipment, nor that anything has been done. The director of the Station published a report entitled 'The Agricultural Reform,' consisting of a theorical organization, which, according to this view, should be established in the Island. This included banks, insurance, taxes, fairs, agricultural schools, etc. He also published two compilations upon tropical crops. The station of Mayagüez consisted of seven acres of land, a small dwelling and office, and a house for the servants. It appears that no other improvements were made and that no field trials nor experimentations were attempted. . . ."

Dr. Evans was badly posted, and the Office of Agriculture and Mines of the Department of the Interior was equally ignorant as to the situation when, from 1902 to 1904, they believed it to be necessary to publish, almost verbatim, for use in a tropical region, a couple of dozen bulletins and circulars gotten out by North American Institutions.

Its Establishment by Congress: Meanwhile, after a preliminary investigation by Professor Knapp in 1901, Congress appropriated the sum of $15,000 to establish and maintain an agricultural station in Porto Rico, authority for that purpose being given to the Secretary of War. On account of the insufficiency of the appropriation, the station operated at first upon rented land in Río Piedras, but was soon transferred to Mayagüez as the Insular Legislature gave $15,000 and the municipality of Mayagüez $4,000 for the purchase of a station farm.

Its Organization: It is analogous to the experimental stations of the States of the Union, with the difference that it depends upon the authority of the Federal Department of Agriculture, although the Insular Legislature has willingly lent it material aid upon different occasions.

Its Work: It would have saved precious time, avoided some mistakes and paid due deference to those who preceded them in their work, if the able scientists who inaugurated this institution had devoted the time necessary to familiarize themselves with Porto Rico's agricultural history. The fruits of the temperate zone had failed and failed again, as did the alfalfa, wheat, barley, oats, rye and clover, the obstacles which had made fruitless the efforts to encourage the planting of maguey sisal, ramie, cacao, still existed, and so history repeated itself, repetitions which cannot be considered as true shortcomings belonging to the institution the work of which we are considering.

EL COCOTERO FUÉ UNA DE LAS PRIMERAS PLANTAS IMPORTADAS.
A FRUIT THAT IS BOTH FOOD AND DRINK.

The first new element which distinguished the labor of the new station from that of Spanish stations was the technique in entomology, especially that on micology. More than one hundred species of insects and thirty-six criptogams, identified parasites, have received the attention of its specialists to date.

From its inception this station has also been distinguished from the former by a decided tendency to disseminate among planters cultural and industrial information adapted to the various crops of the country, these methods being revised frequently by critical observations. Of this character are its bulletins, and circulars upon the propagation and preparation of oranges for market, investigations upon tobacco, the yautías of Porto Rico, and upon the cultivation of: garden vegetables, cotton, pineapples, sugar cane, coffee, vanilla and indian corn. During the last ten years increased emphasis has been placed upon concrete investigations of a fundamental character. We always associate this evident change with the appearance, about 1913, of Bulletin II by P. T. Gile, establishing the relation between calcareous soils and chlorosis in the pineapple, which was followed by important experiences on the fertility of soils, the pathology of the coffee and banana trees, and which in our judgment reached their highest scientific level with the labors of Gile on vegetable nutrition.

Practice has not sanctioned many of the plans of the Federal Experiment Station, nor have many of their projects been worked into practical solutions. It must be remembered that the knowledge of the truth is only one of the phases of the complete business of agriculture. On the other hand, this station has been no inconsiderable force in the development of the crop and commerce in pineapples and citrus fruits and in the exploitation of the apiaries. The fields of the Island show their efforts in the introduction of the Whippoorwill cow peas, the Cannavalias and the Stitzolobiums used as green manures, the Elephant grass and in the Guernsey race of cows. In our analytical laboratories its study of the bat guanos of Porto Rico is indispensable.

THE INSULAR EXPERIMENT STATION, 1910-1922

Its Foundation: The example of Hawaii induced our sugar producers to form the "Sugar Growers Association" and that, in turn, to establish in 1910 an experimental sugar station. Then, in 1914, this passed into the hands of the Government of Porto Rico, under the supervision of a Board of Commissioners of Agriculture, and later under the Department of Agriculture and Labor, of which it is still a branch.

Its Work: While other subjects at various times have occupied the attention of its scientists, its specialty has been the problems of the sugar industry.

This circumstance has permitted them to give in Agriculture, so far as we know, the highest note of scientific specialization which Porto Rico has registered; its Journal being the only agricultural scientific review that is regularly published in the Island, and one that has a wide circulation among the most important centres of agricultural science of the world.

More than any other in Porto Rico, the labors of the Insular Experiment Station have shown that character of continuity so necessary to give them a permanent value, for which reason in spite of notable defects in some branches the institution has produced work of undeniable scientific merit.

In the field of pure Porto Rican micology the appearance in 1918 of its account of parasitic and saprophytic fungi with its list of host plants and the monograph upon the Rhizotecnias of Porto Rico published in 1921 will be looked upon as a great step forward. The Station's study of the insects and mites which attack the sugar cane in Porto Rico and the corresponding bibliography with its annotation will be for a long time indispensable to the student interested in this section of our entomology. These assembled lists represent the accumulated work of many years and many men. Its multiple labor upon varieties of sugar cane culminated in the comprehensive work in two parts, "Varieties of Sugar Cane in Porto Rico."

Other investigations begun under most favorable auspices have not been concluded. The studies on the white grub, for example, broke down when all the methods which had been suggested for its extinction had been exhausted; others, especially those with reference to the most suitable methods of cane cultiva-

tion, did not have the success which they merited in spite of some favorable partial results. But the remedy in this case does not lie in the hands of the Station itself, but in our legislators.

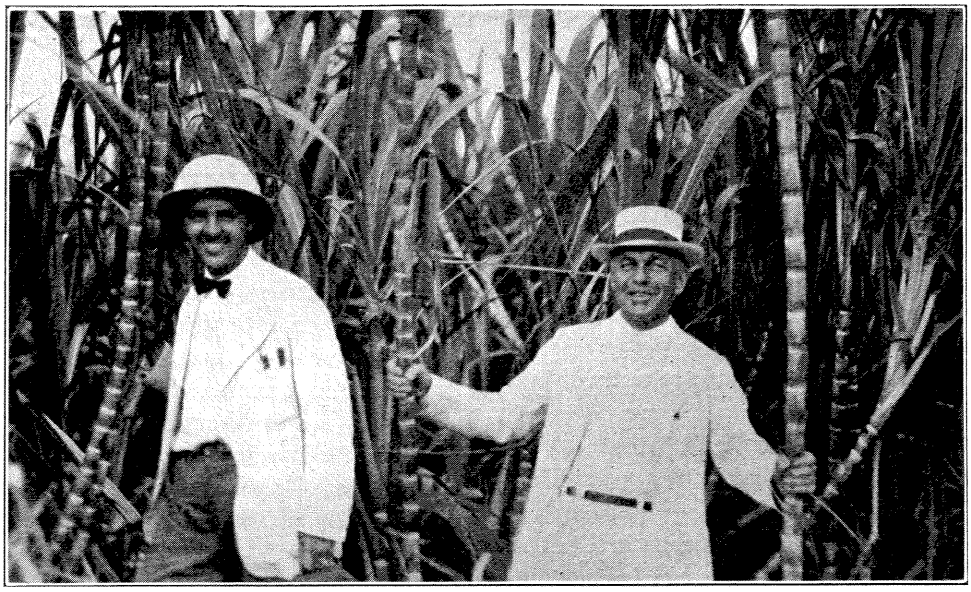
The fields of Trujillo Alto, where the Insular Agricultural Station made its first observations upon the gomosis of the sugar cane, those of Bayamón where its pathologist found the spores of Plasmodiphora, a discovery which changed the face of the previously insoluble problem of the "disease of the sugar cane root"; the field of Fajardo, where the yellow mottling (matizado) of the sugar cane was controlled by the intelligent use of methods planned by the Station; those of Mayagüez, Añasco, Rincón, and Barceloneta, in which, challenging the "matizado," the varieties P. O. J. 105 (Egipcia), 36,213, and the immune Kavangire grow successfully, all these fields bear testimony to its enthusiastic and intelligent labor.

The growing knowledge to be noted in the island on the question of the purchase and use of chemical fertilizers and the average high quality of the fertilizers and soil amendments in the market have been in great part the work of the chemical division of the Insular Station.

PRIVATE EXPERIMENT STATIONS

Guánica Central: Guánica Central has maintained for a long time competent men in charge of experimental projects which it has considered important for its business.

There are few detailed records of its various trials of soil fertilization. They obtained practical results in their trials of varieties of sugar cane in the final selection of some of the foreign varieties and the creation in their seedplots of various new seedlings of magnificent quality. This central, moreover, gave encouragement and material aid to the Insular Experiment Station in its investigations for the destruction of the white grub, and to the Federal Station in its studies of the fertility of the soils near Yauco and Añasco.



CAÑA CENIZA, ORIGINARIA DE LA ESTACIÓN EXPERIMENTAL DE LA FAJARDO SUGAR COMPANY. EL DIRECTOR, SR. RAFAEL VEVE, SE VE A LA IZQUIERDA.—A GOOD CROP, TO JUDGE FROM THEIR GRINS.

Fajardo Central: Fajardo Central has followed the same policy as Guánica Central. They have obtained interesting results by the use of calcium carbonate and filter press cake in the fertilization of sugar cane. In the extirpation of "matizado" their agronomists have scored a big success. They have had equally good results in their varieties of cane D443 and F. S. 306, chosen after many years of trial.

Central Aguirre: Recently Central Aguirre

has secured the services of a well-known scientist to do research work for them along the same lines.

Plazuela Central: Almost simultaneously with the last sugar estate, the Plazuela Central developed a project of its President, Don Eduardo Giorgetti, of installing an agricultural laboratory and field for the improvements of its plantations. Here there has already been inaugurated the study of varieties, soils and methods of cultivation.

Porto Rico Leaf Tobacco Co.: The Porto Rico Leaf Tobacco Co. sustained for a time a laboratory. In co-operation with them the Insular Experiment Station made some studies of the insects injurious to tobacco.

CONCLUSION

Summing up all these efforts made by our centres of investigation, we may state that the foundations of our agricultural science have been now laid. We do not hesitate, nevertheless, to state that the appreciation of these institutions from the point of view of their aid to the planter will depend more and more every day upon the knowledge which their specialists may possess of the practices effected by the investigations and of the firm resolution not to consider an investigation closed when it has satisfied the interest of pure science only; but rather when all the means of making its application of benefit to the farmer have been exhausted.

Soils and Fertilizers

By Isidoro Colón Frías, B.Sc., Ch.E.,

Former Chemist of the Insular Experiment Station. Former Professor of Chemistry of the University of Porto Rico. Superintendent of "Porto Rico Fertilizer Company."

General Considerations: The question of soils and fertilizers is of utmost importance in agricultural countries, such as Porto Rico. According to statistics collected by the Department of Agriculture of Porto Rico, over 40,000 tons of mixed fertilizers were used during the year ending June 30, 1922, valued at nearly three million dollars. This is a considerable sum of money and clearly indicates the great importance of fertilizers in her agriculture, due to the fact that the majority of the soils have been in cultivation for many years and their fertility has been badly depleted.

Classification of Soils: There are, in all arable soils, four fundamental components, each one of which has a special function to perform, directly or indirectly, in the nutrition of plants. These four fundamental components are *sand, clay, lime* and *humus*. The relative amounts of each one of these components furnishes the basis for the classification of soils as *sandy, clay, calcareous* and *humic*. Usually to further classify a given soil, the most important component is given, followed by the one second in importance, in point of relative amounts; thus, we have soils designated as *sandy-clay, sandy-calcareous,* and so forth. There are also, along the coasts of Porto Rico, soils excessively charged with alkaline salts. These salty soils are commonly known as *poyal* soils.

Sandy Soils: The *sandy soils* are loose, light and porous, and are usually poor in fertilizer materials, so that unless liberally and wisely fertilized, they do not produce profitable crops. Fertilizers for these soils should be carefully selected, as they have but little power to fix mineral fertilizers, and there is danger of losing the fertilizer thru leaching, especially during rainy weather.

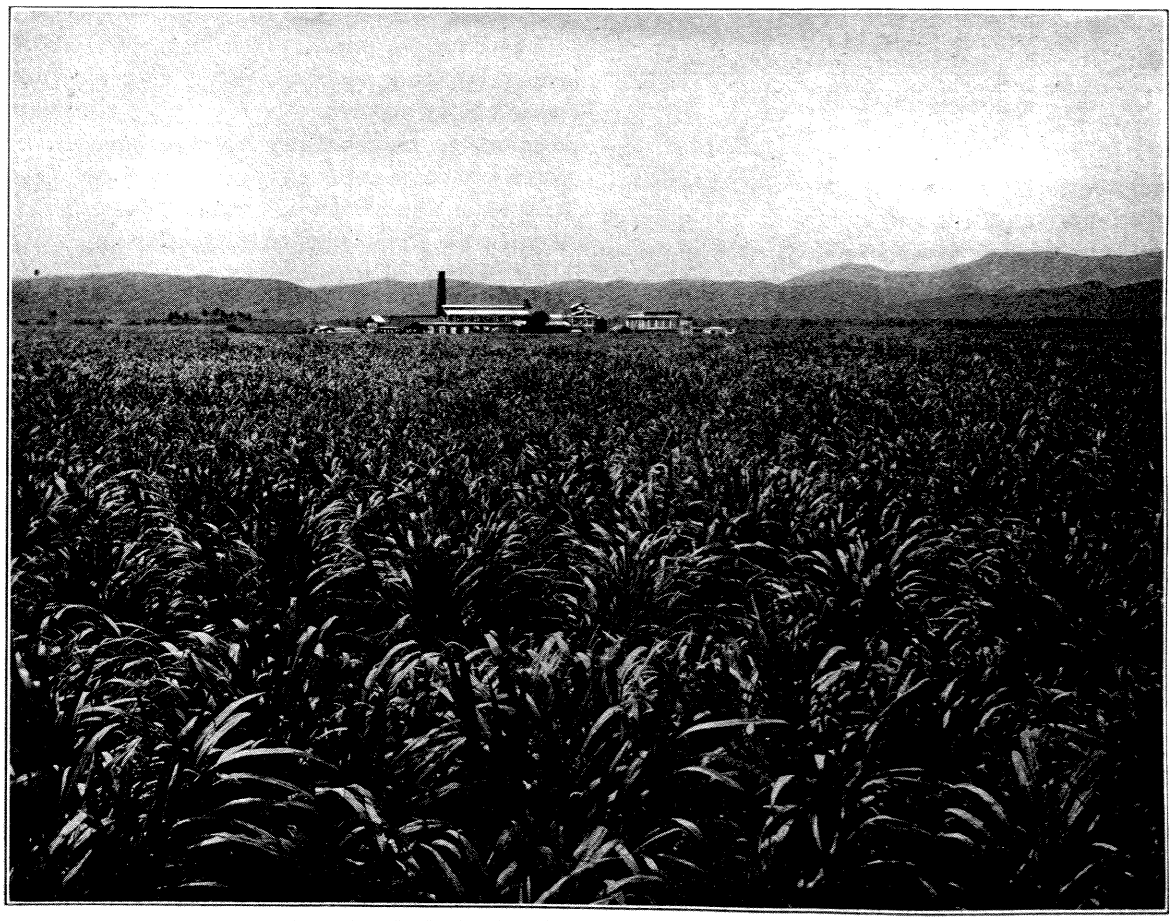
To make these soils productive organic matter should be added, as stable manure, filter press mud (*cachaza*), vegetable residues, green manures, and organic fertilizers. The organic matter gives to these soils more body, makes them more retentive of moisture, so that plants are then better able to withstand drought, such matter also improves their capacity for keeping up their fertility, as *humus* fixes the fertilizing materials, and prevents their being washed away by rains. These soils are benefited by organic fer-

tilizers which decompose gradually, so that the plants use the released food as it becomes available and before it is washed out by the rain.

However, the exclusive use of *organic fertilizers* on these soils may be subject to a great drawback if the decomposition takes place too slowly, as then the plant would suffer from lack of food during the early stages of growth. This may be remedied by using a fertilizer which is partly mineral and partly organic, so that the plant may have food available during the entire period of growth. *Sodium Nitrate* should be used very carefully and in small applications in these soils, especially during rainy weather, as due to its great solubility and to the fact that it is not fixed by the soil it is liable to be washed away by the rain.

Clay Soils: Clay soils are hard, compact, impermeable and difficult to till. During rainy weather the water remains on their surface, in many cases causing the roots to rot; during dry weather they harden and crack, offering then great resistance to the action of tilling implements, and preventing the proper growth and development of roots. With the exception of *nitrates,* clay soils fix strongly the fertilizing materials. They usually contain enough *potash,* but are poor in *phosphoric acid* and *lime.* Clay soils are cold, moist and usually of strongly acid reaction.

This acidity should be corrected with either *carbonate* or *hydrate of lime,* as an acid medium is detrimental to the nitrification of nitrogenous fertilizers. The addition of lime would also improve the physical, chemical and biological properties of the soil decreasing its hardness and tenacity, promoting the decomposition and nitrification of the organic matter, neutralizing certain toxic substances of the soil, rendering plant food available, decreasing fungus diseases and increas-



TIPO DE HACIENDA CENTRIFUGADORA.—CONCLUSIVE PROOF OF SOIL FERTILITY.

ing the capacity of the soil for fixation of fertilizer materials.

It is not advisable to use organic fertilizers on these soils, for the accumulation of nitrogenous organic materials in a compact, impermeable medium might bring about the processes of putrefaction which would be detrimental to plant life. The use of *Thomas basic slag* on clay soils of acid reaction has given excellent results, because in addition to *phosphoric acid, basic slag* contains a considerable amount of lime.

Calcareous Soils: The *calcareous soils* are generally of a whitish color, show little tenacity and are easy to cultivate. These soils are as a rule of low fertility, containing generally very little *nitrogen* and *potash,* but quite sufficient *phosphoric* acid. *Organic fertilizers* are indispensable to these soils, as they decompose slowly, and the plant uses the food according to its needs. *Nitrate of soda* should be used very carefully in small applications and at the exact time that the plant is ready to use it. *Sulphate of ammonia* should not be used on *excessively calcareous soils* as there might result large losses of ammonia when the sulphate of ammonia comes in contact with the lime carbonate of the soil. The addition of stable manure and vegetable residues greatly improves these soils.

Humic Soils: The *humic soils* are usually very fertile, they are formed largely by a black substance which is the result of the decomposition of vegetable residues of all kinds. This substance is called *humus* and constitutes the essential factor of the fertility of a soil, as it is the source of the soil nitrates, it fixes the phosphates and the ammoniacal and potassie salts, and improves considerably the physical properties of soils, making them more pliable and porous, cooler and with better air circulation and makes them hold the moisture better.

These soils are greatly benefited by the use of lime amendments, which promote the nitrification of the organic matter. As a general rule these soils are poor in *lime, phosphoric acid* and *potash,* and rich in *nitrogen.*

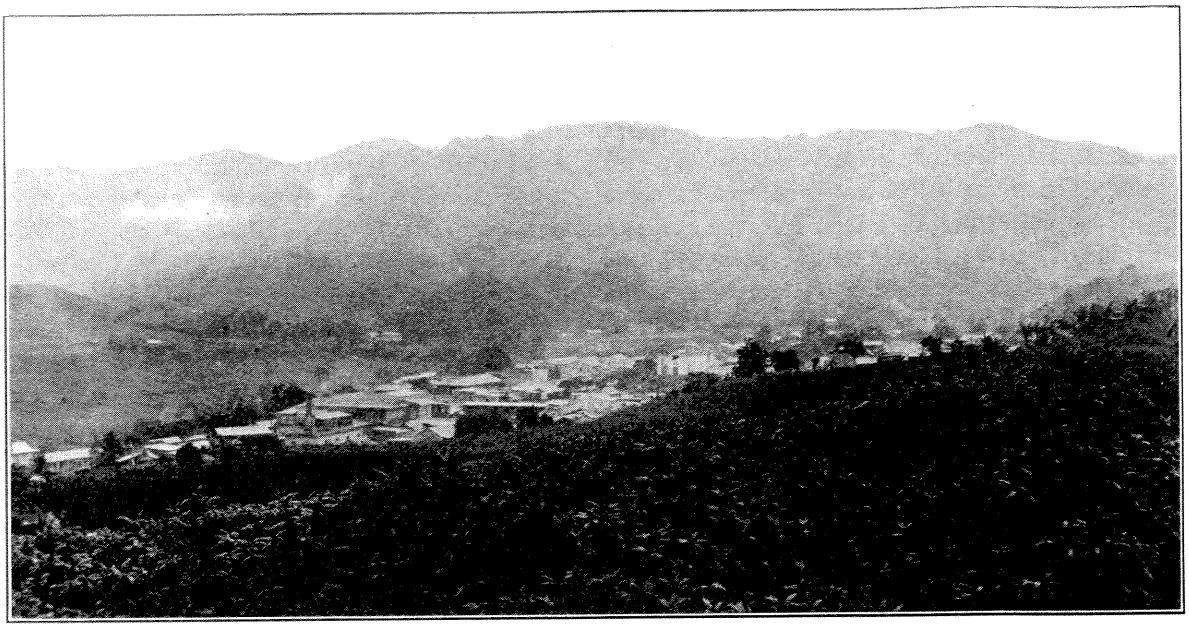
Alkaline Soils: The *saline* or *poyal* soils are characterized by the excess of salts they contain which are deleterious to vegetation, such as *chlorides, carbonates* and *bicarbonates of sodium, potassium* and *magnesium.* The chief problem with these soils lies in the elimination of these harmful salts and their transformation into substances harmless to plant growth. To remove them the field should be flooded for some time, being careful to have the ditches made with a good decline, so that the water may be rapidly drained, carrying along most of the salts in solution.

The rapid evaporation of the surface water should be avoided by all means, as the water coming up by capillarity would then bring considerable amounts of salts which would be deposited on the surface. This may be avoided by using a protective layer of dry cane leaves (mulch), or by plowing to a depth of three to four inches so as to break the continuous ascension of the salts laden water.

These soils are greatly improved by the use of *sulphate of lime* (*gypsum*) as an amendment acid phosphate also gives good results, not only on account of its immediately available phosphoric acid, but also due to the considerable amount of calcium sulphate it contains. The chemical analysis of these soils reveals that usually they are rich in *nitrogen,* and very poor in *phosphoric acid* and *potash.* The nitrogen that these soils contain is not in a form immediately available to plants.

On these soils fertilizers should be used which, like sulphate of ammonia, acid phosphate and sulphate of potash, counteract the effect of the salts of the soils and transform them into sulphates which are not harmful to vegetation. In the southern part of the island excellent results have been obtained by the use of tile drainage in these *poyal* soils.

Geographic Distribution of These Soils: These are in general the principal characteristics of Porto Rico's soils. In the eastern part of the Island around Fajardo, Ceiba, Naguabo, Humacao and Yabucoa the *clay* and the *sandy-clay soils* predominate and are used almost exclusively in cane cultivation. In the northern part from Fajardo to Toa Baja are also found *clay soils* planted almost exclusively to sugar cane. In this region, around Río Piedras, and from Bayamón to Barceloneta are located the fruit plantations (oranges, grape-fruit and pine-apples). West of the Toa river limestone makes its appearance, and it begins to predominate



UTUADO.—LOCATED IN COFFEE AND TOBACCO DISTRICT.

around Arecibo where are found clay and sandy-clay soils containing considerable amounts of calcium carbonate, planted chiefly with sugar cane. This *calcareous* region extends over to Rincón, and in some places around Aguadilla. The amount of calcium carbonate present is so great that some of the soils are whitish in color and very unproductive.

The soils on the southern part of the island are the best suited for cane cultivation due to the fact that rains are not so frequent in this region as on the northern and eastern parts, and as a result their fertility has not been washed away by the heavy rains. In the southern part of the island water is supplied to the cane plantations by a magnificent system of irrigation constructed by the government several years ago.

The soils around Patillas, Arroyo, Guayama, and Aguirre are *clay* and *sandy-clay,* with a high content of humus, which accounts for their great fertility. Near Salinas are again met with soils containing variable amounts of calcium of carbonate, which increases as we move west to Ponce, Guayanilla, Peñuelas and Guánica.

It is a really interesting fact that the red clay soils of the northern and eastern parts of Porto Rico are *strongly acid* in reaction and deficient in *lime,* while the soils on the southern part west of Ponce, and on the northern part west of Arecibo contain considerable amounts of calcium carbonate. In the interior of the island especially around Juncos, Gurabo, Caguas, Cayey, Aibonito, Comerío and Barranquitas, on the hills are found black soils of great fertility, due to their richness in humus. In Gurabo and Juncos these soils are planted with cane and tobacco and they yield good crops. In Caguas, Cayey, Aibonito, Comerío and Barranquitas these black lands are used almost exclusively for tobacco cultivation and are famous for the superior quality of the tobacco which they produce. In the region of Jayuya and Utuado the tobacco produced is also of excellent quality. The alluvial soils formed along the course of rivers are usually sandy-clay soils, easy to cultivate and, generally planted with sugar cane, they yield good crops. As stated previously, the *poyal* soils are located near the sea-shore, and are generally dedicated to cane cultivation.

Soil Deficiencies in Porto Rico: Chemical analysis shows that the immense majority of Porto Rican soils are poor in *nitrogen* and *phosphoric acid* and many are deficient in *potash* and *lime.* This should cause no surprise when it is considered the number of years that these lands have been under cultivation. We have to maintain the fertility of our soils by making use of all the advantages offered by modern agronomical methods, and we should return to the land in the form of fertilizers the substances which have been taken by the crops from the soil.

With what materials and in what proportions should a given soil be fertilized? This is the question made by the farmer, and the answer is, that it depends on the character and composition of the soil, on the season in which the fertilizer is to be applied, and on the particular crop that he intends to fertilize.

Chemical analysis will show the richness of the soil in fertilizer materials and by a series of simple field experiments the farmer can easily verify the results obtained with different fertilizer combinations.

A farmer of experience might infer the deficiencies of his soil by closely observing the color of the leaves of his crop. A light green color indicates deficiency in nitrogen, while a reddish-brown coloration denotes lack of phosphoric acid, and yellowish-brown spots which cause the leaves to wrinkle, point towards deficiency in potash. The farmer should be very careful, though, in interpreting these leaf colorations, for there are many plant diseases which cause discoloration of the leaves.

The time of application is of capital importance in the selection of fertilizers, for during rainy seasons soluble substances, which like *nitrate of soda* are not fixed by the soil, should not be used. If the land is hilly and steep as is the case in the majority of the lands used for tobacco and coffee, a fertilizer should be selected which is not too soluble and that can be firmly fixed by the soil, so that there be no danger of it being washed away by the rains before being used up by the plant.

Many soils are sadly lacking in organic matter, and they should be planted with leguminous crops so that they may recover their lost fertility. The use of leguminous crops to enrich and better lands which are under constant cultivation should be practiced by all farmers in Porto Rico, and it is to be regretted that the majority of the farmers do not realize the important role leguminous crops play in modern agriculture.

Sugar Cane Fertilizers: The most important element in sugar cane cultivation, the element that imparts a dark green color and increases greatly the yield per acre, is nitrogen. Yet, it must be borne in mind that nitrogen retards the maturity of the cane, prolonging the period of growth, while *phosphoric acid* hastens the maturity of the cane. It should be also taken into consideration that sugar cane has a long period of growth that lasts from 12 to 20 months, and a fertilizer should be selected that can nourish the plant during all this time.

It is undoubtedly true that sugar cane's greatest need of fertilizers is when the plant is young and is forming its leaves and roots, but it is also true that the plant needs nutrition during all its period of growth and development, and for this reason formulas should be used containing fertilizer ingredients that will be available to the plant at different stages of its growth. It should not be forgotten either that *stubble* cane requires more *nitrogen* and less *phosphoric acid* and *potash* relatively, than *plant* cane.

The fertilizer formulas most commonly used in Porto Rico for cane are: 12-6-5; 12-8-3; 12-6-3; 10-8-5; 10-6-5 and 9-8-8.

Tobacco Fertilizers: Many farmers fertilize tobacco carelessly, taking in consideration the *quantity* and very seldom the *quality* of the tobacco produced. This is a serious error, as during the last two years it has been seen that tobacco of good quality commands a much better price and is sold quicker than tobacco of poor quality, and this is a good lesson which should not be forgotten by our farmers.

In selecting fertilizing formulas for tobacco, an excess of *nitrogen* should be avoided, for although it increases markedly the yield per acre, it makes the leaves thicker, heavier and more coarse, and increases the amount of *nicotine* which is undesirable for grades of high quality. It is preferable to apply the nitrogen part in the form of sulphate of ammonia and part in organic form, to prevent a too rapid growth of the plant, for a purely mineral fertilizer would have the tendency to quicken the growth of the plant, which might result in the formation of a leaf of inferior quality, lacking in softness and fineness.

Porto Rican soils are usually poor in *phosphoric acid,* and farmers should use fertilizer formulas with a high percentage of *phosphoric acid* if they expect to get good yields. *Potash* is of capital importance in fertilizer formulas for tobacco, for it is not only essential to the combustibility of the leaf, but also has a marked effect on its quality, making the leaf finer, softer and more flexible. Potash should always be used in the form of

sulphate, and never in the form of *chloride*, for chlorine impairs the combustibility of the leaf. The fertilizer formulas most commonly used for tobacco are: 4-9-3; 4-9-5; 4-9-8; 6-9-6; 6-7-6.

Fruit Fertilizer: In selecting fertilizer formulas for fruit trees we should bear in mind the fact that young trees which are in their period of growth require a great amount of nitrogen for the formation of the roots, trunk, branches and leaves, while bearing trees need less *nitrogen* and more *phosphoric acid* and *potash* relatively for fruit formation.

Nitrogen has a marked influence in the formation of trunk and leaves, imparting to them a dark green color, promoting a rapid and vigorous growth of the plant, and an abundant flower formation, yet an excess of *nitrogen* should be carefully avoided for it prolongs the period of growth, retards maturity, causes the flowers to drop from the trees, and the fruit to be bigger, but not so sweet, increases the amount of rag and the thickness of the rind, and makes the plant more susceptible to disease. *Phosphoric acid*, on the other hand, increases greatly fruit formation, hastens maturity and prevents the dropping of flowers and fruits from the trees. *Potash* gives vigor and beauty to the plant and makes it resistant to disease, makes the rind of the fruit thinner and lessens the amount of rag, causes the fruit to be harder and heavier, and increases their keeping and carrying qualities.

The fertilizer formulas used for fruits in Porto Rico vary greatly as each farmer uses the formula best adapted to the composition of his soil and the needs of his crops. Most of the fruit fertilizer consumed in the island is used either for *pineapples* or for *citrus trees*.

It is a pity that the use of fertilizers has not yet been extended to the cultivation of such crops as coffee, corn, cotton, etc.

The increase in the use of fertilizers during the last ten years has been so surprising and the effect so beneficial, that it is to be expected that at no distant day, fertilizers will be used on all crops grown on the island.

Plant Introductions

By David William May, A.M.,

Agronomist in Charge, Porto Rico Agricultural Experiment Station, Mayagüez, Porto Rico. Member of the Society for the Promotion of Agricultural Science, Washington, D. C.

Travel in foreign countries is not only enjoyable but may prove highly valuable, especially if the traveler brings back with him new ideas, methods of work, or valuable plants which he can adapt to his own country. Thomas Jefferson, in summing up the various valuable works he had done for mankind, recounted besides the Declaration of Independence his introduction of upland rice into the Carolinas.

Work of the Department of Agriculture. The United States Department of Agriculture keeps men in the field looking for new plants for the various countries under the Stars and Stripes. Also that Department sends out every year a number of men on special missions to foreign countries to study their methods of agriculture and to secure valuable plants to bring home with them. This department, thru the Federal Experiment Station at Mayaguez, has sent to Porto Rico a number of plants that are already proving extremely valuable to the Island. The Station also sends members of its staff abroad for similar purpose, they having in mind especially the seeking of information as well as plants that may be adaptable to Porto Rico.

Aid Afforded the Sugar Industry. Sugar cane, being the island's main industry, a great deal of attention has been paid to securing the best cane varieties of other countries. Also efforts are being made to grow new varieties by planting the seed that grows in the tassels. The work has given most excellent results, not only here, but in the British Islands, to the south of it, where this was first accomplished.

Canes have been brought in that have proven more productive than the kinds previously

grown in certain sections of the island. Others have also been imported which are immune to some diseases that occasionally break out in the cane plantations. As an example of this, under an appropriation of $20,000 from Congress, there was recently introduced from Argentine, canes that are partly and, in one case, wholly immune to the "matizado" disease which threatened the cane industry in Porto Rico. In this work, it is right and proper that credit should be given to the experiment stations in other cane growing countries for their hearty co-operation and help in breeding and exchanging these new varieties of canes which mean so much to the sugar industry, and which do such a large part in supplying the world with the sweets which it desires.

ESTACIÓN EXPERIMENTAL FEDERAL, MAYAGÜEZ.—THE HOME OF PLANT INTRODUCTION.

Aid Afforded the Fruit Industry. The fruit industry, which is making such enormous strides in Porto Rico, owes its success in large part to the early introduction, after the American occupation, of the best varieties of grapefruit and oranges that were being grown in Florida and California. The end is not yet and we are still seeking for even better varieties of these fruits though we have pretty well settled upon the most desirable kinds, so far as known, at this time. The Red Spanish pineapple is another fruit of recent introduction that has proven so valuable that the exports of it annually run to close to a million dollars.

Grasses. An introduction that was recently made by this Station from Africa is the Elephant grass, and from Guatemala of the grass known under that name. These two are now being grown in all sections of the island and are proving tremendously productive. They are the most direct cause for the present impetus in live stock production and have taken a leading part in bringing about the importation of improved dairy cattle. Yields of these grasses have been reported as high as 40 tons to the acre and when cut at the proper time the entire plant is consumed by the cattle. With these grasses the number of cattle kept on a farm can easily be doubled and trebled.

Other Introductions. Another grass of great promise as a pasture and grazing grass has

been introduced from Java and is now being distributed over the island. Cattle not only eat it but it is used for lawns and also adapts itself to school yards.

Some years ago a member of the station staff, Mr. T. B. McClelland, was traveling in Venezuela looking for something of value to Porto Rico. He found a black bean that was very prolific, gave large yields and was free from disease. Upon return he found that this bean gave equally excellent results in Porto Rico, but, unfortunately, however, the people were not used to a black bean and for that reason it failed to find favor. Mr. McClelland therefore set forth to breed from this bean one of equally good characteristics but of a different color. The result has been that by methods of plant breeding he has secured beans of this variety ranging in color from white to red and mottled, so that we are now in a position to supply the market demand in beans, as regards color, while none of the desirable characteristics of immunity to disease and flavor have been sacrificed.

Among other members of the bean family the velvet bean is proving of great value to the island. This is grown to improve the soil, as it stores nitrogen, from the air, and also as a stock feed. All classes of live stock eat the vines with relish and also the beans when ground into meal.

A Bean That Supplies Fat. The Soy bean which plays such a large part in the agriculture of China and Japan, has been introduced into Porto Rico and is now slowly making its way. This bean is especially valuable because of its high content of fat, about 40 per cent. As we import a great deal of cooking fats in the form of cotton seed oil, corn and olive oils, the Soy bean should in a great measure make up for the lack of this element in our dietary. There are a great many ways of preparing it for the table. This is used not only as a cooked vegetable, prepared somewhat as we do the "Garbanzo" but in the East there is made from it sauce, milk, cheese and other products.

Among other plants of value that we have introduced and which space permits us to mention only, are the improved mangoes, avocadoes and a number of the well known garden vegetables of the North.

A Warning Needed. Credit should be given not only to the experiment stations but to various persons in Porto Rico who have brought in valuable plants. Attention must be called, however, and a warning uttered in regard to this because of the liability of introducing certain insect and fungus pests as well as plants that may prove to be weeds causing great losses to our agriculture. Fortunately, we have on the statute book at this time a very efficient law governing the introduction of plants. This is very efficiently administered by the Bureau of Agriculture and we may rest reasonably assured that while still other valuable introductions will be made our interests are safeguarded by this quarantine service.

Irrigation in Porto Rico

By Rafael A. González, C.E.

The practice of irrigation has been known in Porto Rico for over 80 years, it having been introduced into the island by the Spanish farmers. The methods employed by them at first were rather primitive, and their efforts limited to diverting the rivers into canals where the slope and topography of the land permitted easy, inexpensive work.

Irrigation was developed to an important extent in the south coast, where the damage caused by the long droughts to the cane plantations is most serious. To remedy this, many landowners obtained from the Spanish Government concessions of the low water flow and part of the storm waters of most of the rivers, and pumps of large capacity were established to bring to the surface the abundant underground waters of that region. The volumes of water thus obtained were not sufficient to supply the needs of the plantations, and consequently, at the request of the landowners, the Legislature of Porto Rico in 1908 approved a law providing for the construction and operation of a Public Irrigation System comprising those lands of the south coast lying between the Patillas and Jacaguas rivers. This system, which cost around $5,000,000, provides water for the irrigation of about 33,000 acres, and is described fully in another article in this book.

Outside of the Public Irrigation District and west of the Jacaguas River, there are many scattered private irrigation works on the south coast which partly fill the needs of the cane grower. Other works of limited extent have been built on the northern part of the island by several Sugar Centrals. Among them may be mentioned those of the Fajardo and "Los Caños" Centrals. Still other projects are under consideration by other Centrals to be built as soon as convenient.

In regions where the advantages of irrigation are recognized, the dry weather flow of the rivers is promptly taken up by a few individuals. As this supply is not generally sufficient for the needs of the regions, there arises in time a demand for a fuller utilization of the flow, which requires the construction of storage dams, larger canals and other important structures. Due to the numerous and sometimes conflicting interests involved in these larger developments, they are more successfully carried on under government control.

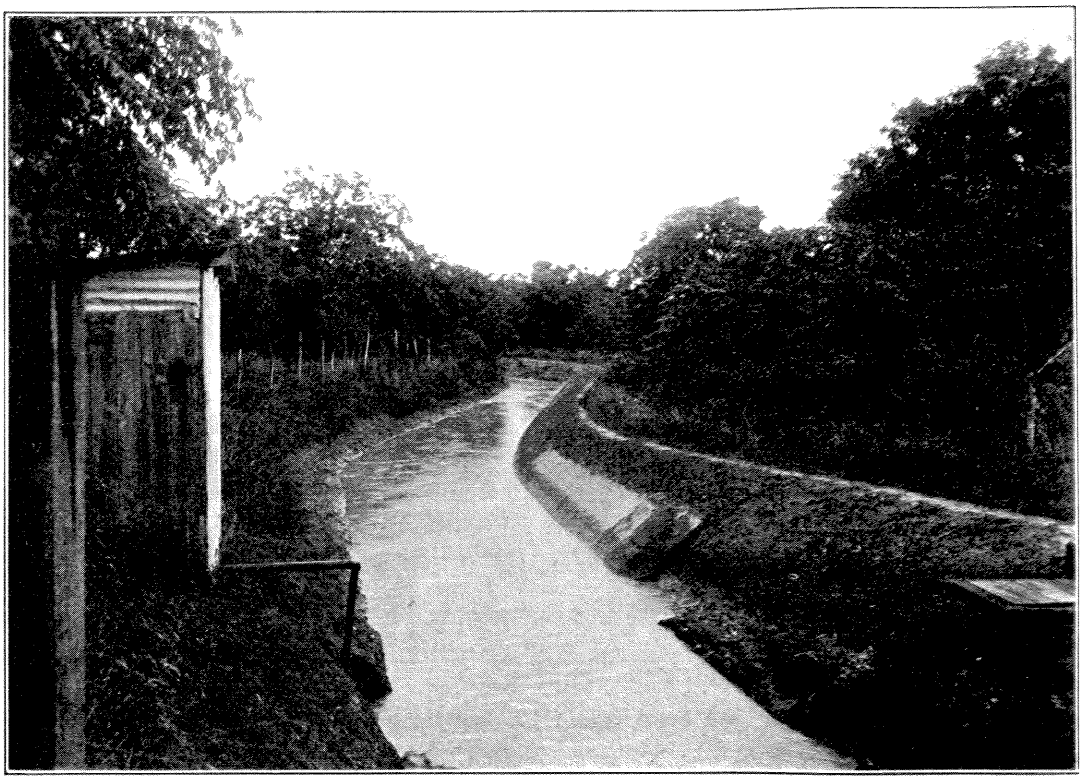
Other Projects. These conditions have been reached in that part of the south coast not under the public irrigation system already mentioned. Consequently, the Legislature of Porto Rico in 1916 appropriated funds for the purpose of making a preliminary study of the irrigation of the lands in the districts of Ponce and Juana Díaz, in the Lajas Valley, and in the municipality of Isabela. The latter study was later extended to include lands in the municipalities of Moca and Aguadilla. Although Isabela, Moca and Aguadilla are on the northwestern part of the island, the droughts are serious and frequent, and not even partial relief may be obtained from flowing streams, as there are none in the whole region. A description of these projects is given herewith.

Ponce-Juana Diaz Project. This project includes about 15,000 acres of irrigable land between the Jacaguas and Marueño Rivers. The greater portion of this land is partly irrigated from water derived from the various rivers and creeks of the district, or from pumping plants. All of the low water flow of all of the streams in the district is utilized by concessions granted many years ago. The water available for more extensive irrigation consists of the flood waters of the rivers, and in order to utilize them storage reservoirs would have to be constructed. Investigations on this project were discontinued after a time for lack of funds.

Lajas Project. This contemplates the irrigation of about 12,000 acres of land in the valley of Lajas, utilizing the waters of the San Germán River and others. The principal features of this development consist of a reservoir on the San Germán River, with an area

of 923 acres and a capacity of 21,000 acre-feet; a tunnel 7400 feet long from the reservoir to the Lajas Valley; the distribution system of canals and laterals; the diversion of the Cain, Potrero, Lajas and Guaba Rivers; and a hydroelectric plant of about 1000 horse-power. The estimated cost of this most important project is about $3,250,000, and it is considered entirely feasible at this cost.

General Notes On Irrigation. The need of irrigation arises from the deficiency of rainfall at the proper time for the best growth of the plant. In some regions the annual rainfall is apparently sufficient, but as it frequently falls in excess during parts of the year, and is deficient in others, irrigation becomes necessary during the periods of drought. In places where these conditions prevail irrigation may



CANAL DE RIEGO, GUAYAMA.—IRRIGATION CANAL.

Isabela Project. The construction of this project, more fully described by the author in another article in this book, was authorized by the Legislature, and in 1921 funds were appropriated to carry on the final investigations and surveys. This work is now completed, and it is expected that construction will be soon started.

Bills have been presented at various times to the Legislature for the study of other irrigation projects, such as that of Barceloneta and Manatí, Río Grande and Loíza, and others. These projects and others will no doubt be undertaken as promptly as the financial capacity of the island permits.

be considered as a form of insurance, while in arid lands it is of absolute necessity for plant growth.

The benefits of irrigation are derived from the fact that water is applied to the plant in such quantities and at such periods as are most beneficial, and thus affords ideal conditions for agriculture. By supplying humidity at the proper time, and in required quantities, agriculture may be developed on a more scientific base.

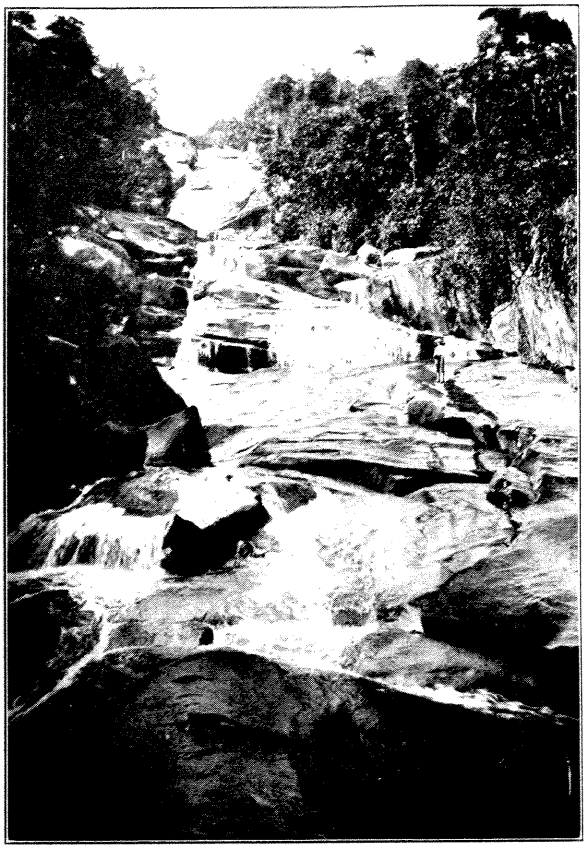
Quantity of Water. The required quantity of water for plant growth depends on the climate, soil and kind of plant. The average annual rainfall for the island is 71 inches, but

it is very unevenly distributed. In the plains of the south coast, which is almost exclusively planted in cane, the annual average rainfall is 45 inches; in the north, 65 inches, and in the east and west, 85 and 75 inches, respectively (see Dr. Fassig's article). Due to the favorable topographic conditions of the interior the average rainfall there exceeds 100 inches per annum. In general terms it may be said that the dry period starts in December and ends in April. The rainfall increases as a rule from May on, reaching a maximum in October or November. The exceptions to these rules, are, however, frequent, especially on the south coast, where droughts of eight or more months are not rare.

Cane Demands at Least 72 Inches of Water Annually. The principal crop of the coastal plains is sugar cane, which requires at least 72 inches of water yearly for its good development. The rainfall in the north and south coasts is therefore deficient for the cultivation of cane, and irrigation is necessary. Although the rainfall in the east and west is apparently sufficient yet, due to its falling mainly during the months from May to November, irrigation would be beneficial if applied for the balance of the year.

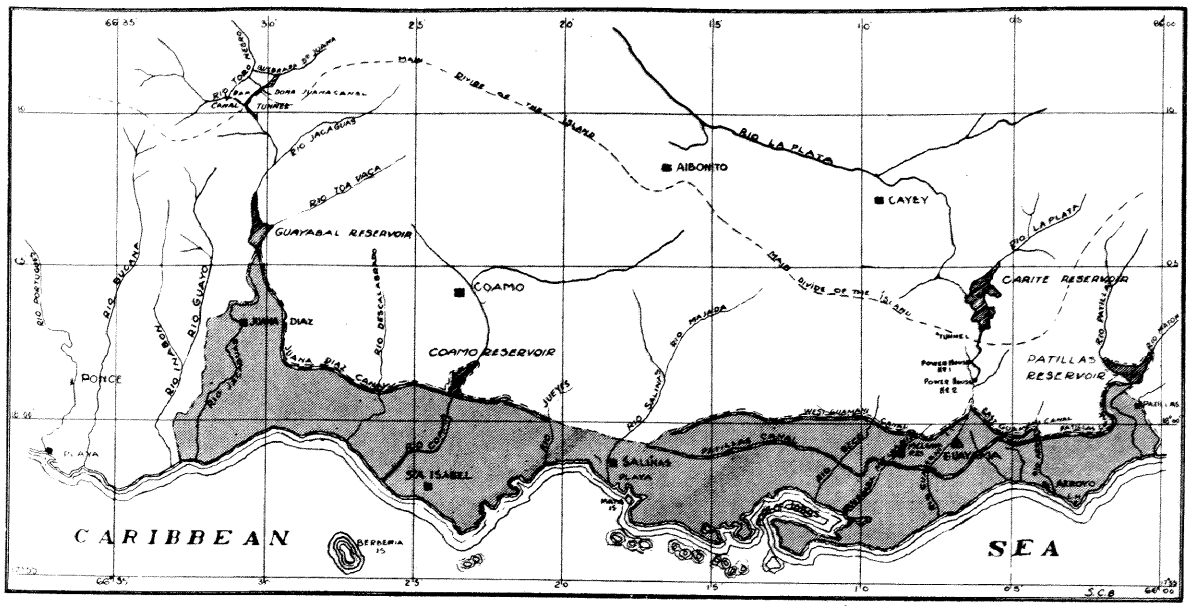
Benefits. The benefits to be obtained from a good irrigation system vary greatly, according to the soil, amount of water applied and the kind and value of the crop. In general, irrigation increases the value of the crops 50% or more, allowing more intensive cultivation, a condition especially advantageous for a country of dense population like Porto Rico.

It is to be regretted that no experiments have been carried on in Porto Rico to determine with a fair degree of approximation the relation between amount of water applied and increase in yield for various crops, and especially for cane. Yet some studies have been made on this matter. Mr. J. W. Beardsley, formerly chief engineer of the Porto Rico Irrigation Service, compiled a diagram showing that within the limits of water usually applied to cane, the increase in yield per inch of beneficial water applied is from 1% to 2% of the normal yield. These figures apply to the clay loam soils of the south coast. Other observations made in several districts of that coast seem to agree with Mr. Beardsley's conclusions. On the northeast part of the island, where irrigation is practiced only for three or four months of the year, the increase in yield of cane is estimated at from 6 to 8 tons per acre.



EL "CARBÓN BLANCO"—ELECTRICIDAD—ES ESENCIALMENTE NUESTRA FUERZA MOTRIZ.
A MEANS OF CREATING NEW SOURCES OF WEALTH.

A Means of Creating New Sources of Wealth for the People. It is generally recognized that the maintenance of the increasing population of the island requires the utilization to the utmost of its natural resources. The construction of new irrigation projects deserves to be considered seriously by the people of Porto Rico as a means of creating new sources of wealth and of affording greater opportunities to work for her laboring classes. It is often practicable to develop hydroelectric power in connection with an irrigation system, thus furnishing low-cost power for the development of new industries.



MAPA DEL DISTRITO DE RIEGO DE LA COSTA SUR.
THE SOUTH COAST IRRIGATION SYSTEM. SHADED PORTION REPRESENTING THE IRRIGATION DISTRICT.

Public Irrigation Service

By Antonio Luchetti Otero, C.E.,

Assistant Chief Engineer, "Porto Rico Irrigation Service." Member of Several Professional Societies.

Area and Importance: The total area irrigated by the Public Irrigation System in round numbers, amounts to 33,000 acres. It is distributed over the strip of level fertile lands, lying along the South Coast of the Island between the Patillas River on the East and the Jacaguas River on the west, a distance of about 40 miles.

The cultivation of sugar cane on these lands dates from many years back. This part of the Island is usually very dry during several months of the year, sometimes the drought becoming very intense and lasting for extremely long periods, and since plenty of water is a most vital factor for the growth and full development of sugar cane, it happened that when no adequate means to supply this water by irrigation were available the success of its crops was very uncertain and consequently its sugar industry stood on a doubtful basis.

Therefore, this part of the country is very fortunate in having been provided with a reliable and efficient Irrigation System whereby water is delivered to the plantations just when it is needed, at all seasons of the year and in quantities as required.

One can easily realize how the construction of the Irrigation System tended to raise the value of the land included in the Irrigation District and also what it has meant to the Island at large.

History and Development of the Project: Although prior to the construction of the present system, irrigation had been practiced on a large portion of the land in this district, using water from the various streams flowing nearby, for which concessions had been secured from the Government, the sources of supply and the means at the disposal of the planters were inefficient and as a rule water was unobtainable when most needed.

Low diversion dams, which permitted no storage, and long private canals were then depended on to bring water to these lands. During the rainy season, of course, plenty of water was available, but it failed when dry weather prevailed.

The planters had also resorted to pumping underground water from wells, and a good number of such installations were already in existence, but this source of supply also ran short and in not a few places it failed altogether when heavy droughts occurred.

To obviate these difficulties, the question had long been considered of studying and adopting a general scheme of irrigation which would make possible the storage of flood waters and at the same time increase such storage with water brought down from the watersheds on the North side of the main divide, where there is a large rainfall and the flow of the rivers is more constant throughout the year.

To this end the Legislature of Porto Rico, in the year 1908, passed the Public Irrigation Act providing for the construction and operation of the present system.

The System, as constructed, consists essentially of a number of storage reservoirs located at the most suitable sites, and of the main distribution canals fed from such reservoirs.

Beginning at the eastern end of the Irrigation District, we give here the following main features of the System:

Patillas Dam: This dam is built of earth and stone, the material having been selected and placed so as to render it impervious. It is so arranged and of such size that it resembles a mountain closing the gap between the adjacent hills. It impounds the waters of the Patillas and Matón Rivers, and it is located a short distance below the junction of these two streams, at a distance of about a mile northwest of the town of Patillas. It has a maximum height of 132 feet, a length of 1,020 feet along the crest, and a base width of 575 feet at its widest part, and contains some 742,000 cubic meters of material.

Its crest is at an elevation of 239 feet above sea level and to fill the reservoir up to its maximum storage capacity of 14,531 acre-feet, the water rises to 222 feet, thus leaving 17 feet of free board.

When the water rises above 222 feet, it wastes over a spillway dam built of concrete with automatic steel flash boards of the Ambursen type, thus relieving the reservoir of the excess water undesired for the safety of the main dam. The capacity of the spillway is sufficient to handle the largest floods that are likely to occur, and still conserve a free board of 7 feet at the main dam.

Water from this reservoir is fed into the Patillas Canal, by means of a tunnel driven thru the hill at the west end of the dam.

The Patillas Canal: Starts at the dam, follows the foothills and the ridge of the land it irrigates, and ends at a point near the town of Salinas. An average of about 70 cubic feet per second flows daily thru this canal, but at times of heavy demand this flow increases to about 105 cubic feet per second. Lateral canals located at convenient places convey the water from the main canal and distribute it to the land.

The total area irrigated by this canal is about 12,800 acres.

Carite Dam and Tunnel: This dam impounds the headwaters of the La Plata river forming a pond with a storage of 9,339 acre-feet. It is located in the mountains on the northern side of the main divide, at a distance of about six miles to the north of the city of Guayama. It is an earth fill with stone facing, placed in the gorge thru which the river used to flow. Its maximum height is 110 feet, and it is 20 feet wide and 500 feet long at the crest. One hundred and fifty-five thousand cubic meters of material were required in its construction.

Its crest is at an elevation of 1,798 feet above sea level, and its stored water rises to an elevation of 1,783 feet, the excess above this level flowing over the spillway to relieve the storage.

From this reservoir water is delivered to the south side of the divide thru a tunnel 3,060 feet long, built across the main range at an elevation of 1,738 feet above sea level.

From the lower end of the tunnel it flows thru a short canal located along the hillside, and from the end of this canal the water drops 760 feet thru a riveted steel pipe line to the waterwheels of the Carite Hydroelectric Plant. From the tail race of this Plant, the water is led again thru another canal which

follows the hillside, and then drops once more thru another riveted steel pipe line and under a head of 345 feet, to the waterwheels of the Auxiliary Hydroelectric Plant, recently completed.

The flow thru the tunnel and down thru the various conduits is continuous thruout the year and amounts to an average of 28 cubic feet per second. It passes out of the tail race of the lower plant and continues down the course of the Aguamanil river for a distance of approximately 2 miles, and from here it is diverted into the Guamaní Canals to be used in irrigation.

Guamaní Canals: One of these canals runs in an easterly direction and the other runs west towards Salinas. Both canals are located at a higher level than the Patillas Canal and serve the higher lands situated between the latter and the foot of the hills of the north. The total acreage irrigated by the two canals aggregates approximately 5,000 acres.

The East Guamaní Canal has a length of four miles, and the West Guamaní Canal of 14 miles. The first 2.5 miles of the West Canal were built with a larger capacity, so that a good deal of the flood waters in the river can be diverted thru it and stored in a small reservoir known as "Melanía Reservoir", located lower than that of the canal thus making possible the flow into it of water escaping at the end of the 2.5 mile section.

This Melanía Reservoir has a capacity of 300 acre-feet, and its waters are used to reinforce from time to time the flow of the Patillas Canal, which runs nearby and at a lower level.

The features already described constitute that part of the System which commands the eastern half of the Irrigation District, which comprises 17,800 acres of lands under irrigation. To enable the reader to gain a better idea of the arrangement and relation of the features forming the source of supply for the 15,200 acres of land under irrigation in the western half of the District, we will describe them in their relative order, beginning at the western end of the System.

Diversion of the Toro Negro River: The waters of the Toro Negro River together with those of the Quebrada Doña Juana, and Quebrada Navaja, which flow down the northern slope, are diverted to the valley of the Jacaguas River in the south side of the Island by means of the Toro Negro Tunnel. This tunnel crosses the main divide at an elevation of 2,726 feet above sea level, it is 2,770 feet long, and has sufficient capacity for a flow of about 360 cubic feet per second.

The Guayabal Dam: Is located on the Jacaguas River, at a distance 2½ miles, north of the town of Juana Díaz. It is a reinforced concrete structure, of graceful design and stately appearance, and from the point of view of its size, structural arrangement and kind of construction, it may be considered without fear of overrating it, the most noteworthy structure of its kind built so far in this island. Its construction progressed very rapidly, it having been completed in less than two years.

At its highest part it rises 115 feet above the bed of the river, and carries on its crest a reinforced concrete bridge, 1,674 feet long, the longest on the island, which forms part of the Insular Road from Juana Díaz to Ciales.

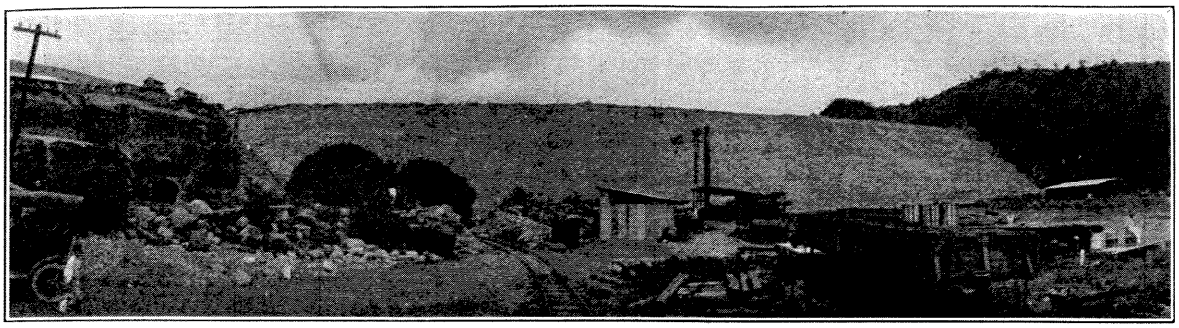
The pond behind this dam contains a storage of 9,524 acre-feet up to the crest of the spillway which is at an elevation of 325 feet above sea level. The spillway has a capacity of 70,000 cubic feet per second.

Juana Díaz Canal and Coamo Dam: This canal is the main artery feeding all the lateral canals and their sub-laterals which deliver irrigation water to the 15,200 acres of land in the western zone of the District. It starts at the Guayabal Dam, winds around the foot of the hills, follows the higher plains in the vicinity of the Descalabrado and Coamo Rivers, and finally ends, after running a distance of 21.2 miles, at a point on the Rio Jueyes about 3 miles west of the town of Salinas.

The Coamo Dam: Is a reinforced concrete structure similar to the one at Guayabal, except that the total length of its crest forms a spillway with automatic steel flash boards mounted on it to increase the storage capacity of the reservoir. This dam is only 65

feet high, and it impounds but 2,700 acre feet of water. This water is turned into the Juana Diaz Canal which crosses the Coamo River a short distance below the dam.

The Juana Diaz Canal delivers a flow of water which amounts to an average of 70 cubic feet per second, increasing the flow in



PRESA DE PATILLAS, AL FINALIZAR LA CONSTRUCCIÓN.
DOWNSTREAM VIEW, PATILLAS DAM WHEN CONSTRUCTION WAS NEARING COMPLETION.

times of great demand to about 118 cubic feet per second.

Following is a brief description of the Hydro-electric System, which although being an incidental development in connection with the main irrigation scheme, has come to be quite an important item in connection with the operation and finances of the Irrigation System.

The Hydroelectric Plants: The Hydroelectric Plants which utilize the water drawn from the Carite Reservoir, have a combined capacity of 2,500 horse power. All this energy is distributed by means of high tension transmission and distribution lines which extend thruout the district from Patillas to Juana Diaz. A great number of pumping installations are connected to the system and it is also used for the lighting of the towns of Patillas, Arroyo, and Guayama, Salinas, Coamo, Santa Isabel and Juana Diaz.

Operation of the Irrigation System: The Irrigation System has now been in operation since the year 1914. The amount of water fixed by the Irrigation Law, as appurtenant to the land, is 4 acre-feet per acre per year, which is equivalent to an application of four inches of water per month to each acre of land irrigated.

The deliveries of water thru the main canals is continuous day and night, and likewise the deliveries to the planters is also continuous during the time required to deliver to them all their appurtenant water for the month. To enable the planter to use the water to best advantage it is the practice authorized by the Law, to allow each one to use all the water he is entitled to as apportioned to the land under his control, and to deliver him this water in the amounts and thru the outlets requested, to an extent, of course, consistent with the needs of the other planters. This method of delivery makes possible the application of water to the fields in the most economic manner for the planters, as regards both cost of labor involved and securing the most benefit out of the water, since they are thus able to apply it by rotation to their various tracts of land, using it in quantities and at such number of times during the month best suited to their needs.

This amount of 4 acre-feet, per acre per year, seems to be sufficient for a good part of the land included in the Irrigation District, but in sandy soils which require much water, it does not seem to meet fully the requirements of the crops. To supply this deficiency the planters avail themselves of the use of underground water, by means of pumps, this source of supply being constantly replenished by the irrigation water applied to the surface a part of which percolates down into the lower strata. The majority of these pumping installations are moved by electric motors which receive current from the Hydroelectric System of the Irrigation Service.

Although the planter, of course, pays for the power consumed by his pumping installa-

tion, this source of power has become a very important item, since it has increased the usefulness of the Irrigation System for the planter, and at the same time helps very materially to defray the expenses of operation and maintenance, and payment of the debt incurred in the construction of the System.

Financial Aspect of the Project: The total cost of construction of all the Irrigation Works, amounting to $5,000,000 was all paid with the proceeds from the sale of bonds issued by the People of Porto Rico. To meet the annual expenses of the Irrigation Service, which includes the cost of maintenance, operation and improvements of the System plus the payment of interest and principal, the Law provides that a water tax not to exceed $15.00 per acre per year, shall be levied on the total acres included in the District and subject to taxation, which area amounts to approximately 24,000 acres. The remaining 9,000 acres now receiving the benefit of the Irrigation System do not contribute in any way toward any of these expenses, this privilege arising from the fact that this land was formerly, and part of it still is, the possessor of certain water rights or concessions granted by the Government, which water came from sources of supply that were needed and were used in connection with the new System.

In addition to the income from the water tax, the Irrigation Service depends, to meet its expenses, each year on the revenues derived from the sale of certain waters and of electric power. This last item has increased to such importance, that without doubt it will, within a few years, exceed the amount of the water taxes that will be required to be levied on the land.

Inasmuch as these items of income are added together to cover the total annual expenses, which total is more or less constant, it is easy to realize the extent of the benefit which the Hydroelectric Service represents for the water tax paying land owners, which in terms of dollars and cents means that the greater the sale of electrical power is for the year, that much less will be the amount required to be collected in water taxes from the planters.

The incentive to promote the development and extension of the Hydroelectric System is therefore quite evident. There is a growing demand for electric power and the land-owner enjoys the double benefit of power served him at a very low price plus a consequent decrease in the amount of his water tax, and in the future, when the Irrigation Debt has been paid in full, the People of Porto Rico will become the possessor, as provided by Law, of an extensive and efficient Hydroelectric System, from which large revenues will be derived and turned into the Insular Treasury for the benefit of the whole Island.

Isabela Irrigation Project

To Cost $3,325,000 and Possessing Novel Features

By R. A. González, C.E.,
Chief Engineer, Isabela Irrigation Service.

As the Isabela Irrigation Project referred to in the "Brief Synopsis on Irrigation" by the author in another article in this book, is now under way and possesses novel features, it is thought that a more complete description of its main features will prove of general interest. This project which will irrigate over 15,000 acres of land along the high rolling plain on the northwest coast of the island, will involve the expenditure of about $3,325,000 and do an immense amount of good toward the future development of Porto Rico.

In describing it, the author of this article is taking the liberty of quoting largely from his article in the Engineering News-Record of January 25th, 1923, for the reason that he feels that the data presented in that article describes the features of the project in the shortest and perhaps the most direct manner.

Feasible in Spite of Numerous Sinkholes. Despite the numerous sinkholes on the site of the storage reservoir required, geologists indicate that the project is feasible and the sinkholes can be sealed satisfactorily. Outlets of sinkholes in the flooded area were all found above the present river level. An earth dam, chosen because of the depth of the overburden, is to be built 37 m. high and 372 m. long on top. It will have a volume of 331,000 cu. m. The material will be sluiced into place toward the center after dumping it from embankments at the upstream and downstream toes. The 17-km. diversion canal of 150-sec. ft. capacity will have numerous structures because of the rough topography and will require a narrow-gage construction track its full length to handle the material for the tunnels, trestles, flumes, siphons and lining. At the end of the canal a fall of 32 m. will be utilized to develop 950 hp. to be used in neighboring towns and to lift water above the canal level.

The land slopes from an elevation of 150 m. at the foot of the mountains to 85 m. above sea level at the steep bluff which follows the coast line around this part of the island.

Will Do Much for the Small Landowner. One-third of the total area of the project is in small holdings of less than 20 acres. Another third is in holdings of more than 100 acres. The principal crops are sugar cane, tobacco, corn, beans, onions, sweet potatoes, fruits and cotton. Sugar cane will probably be the principal crop after irrigation is established.

A Reservoir with 28,000-Acre Ft. Capacity. Water for the project will be stored in a reservoir of 28,000 acre-ft. capacity to be constructed on the Guajataca River at a point about 10 km. south of Quebradillas. The dam will flood a flat valley of 923 acres above the Quajataca Canyon.

Duty of Water and Water Supply. The lowest annual rainfall recorded in the irrigable district is 37 in. and the mean 54 in. It is believed that 70 per cent of it will be beneficial, resulting in a minimum of 26 in. and an average of 38 in. of beneficial rainfall. Sugar cane requires at least 72 in. of beneficial water per year. The duty of water has been taken at 4 acre-ft. per year delivered at the land, which will insure a good supply of water in the driest years.

Records of flow of the Guajataca River near the dam site have been kept for the last six years. Rainfall records at Lares, a town located near the center of the drainage area, are available since 1903, and indicate an average rainfall of 97 in. per annum.

The drainage area above the reservoir embraces about 25 sq. miles of mountainous country. The comparatively high percentage of run-off (average about 75 per cent) indicates that there may be an additional drainage area contributing to the flow of the Guajataca River through sinkholes and underground drainage found in the limestone formation, characteristic of this region.

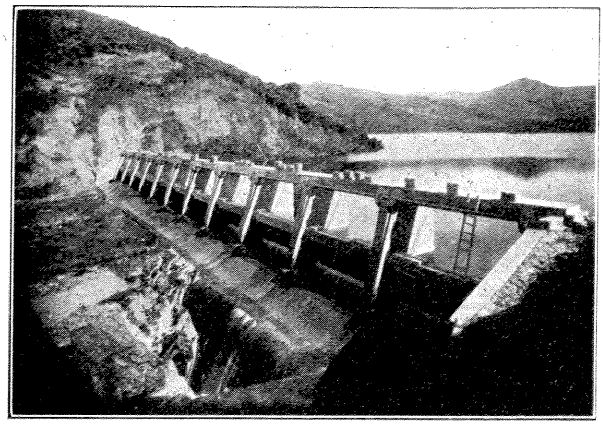
Geology of Dam and Reservoir Sites. Since the limestone formation and the presence of a well developed sinkhole country immediately north of the reservoir site caused considerable apprehension as to the suitability of the site for a reservoir, the services of a geologist, G. R. Mansfield of the U. S. Geological Survey, were obtained to study the geological conditions and to report on the probabilities of excessive seepage losses. Mr. Mansfield concluded that the project is feasible.

The country immediately north of the site is occupied by a broad belt of sharp featured limestone hills that rise approximately 1,000 ft. above sea level. Intervening depressions several hundred feet in depth, ranging in diameter from a few hundred feet to half a mile or more are bounded by steep slopes. These depressions are sinkholes developed to an unusual degree. Through this region the Guajataca River has cut a deep canyon. South of this hill belt is a more open country, where stream valleys are the features instead of sinkholes, though these depressions are also present. The reservoir site is in this belt of more gently sloping country. South of this belt there is another belt of rough limestone hills running east and west.

The limestone in which the reservoir site is located is softer than that in which the big sinkholes farther north are found, and contains a relatively high per cent of clay. The soil produced by the disintegration of this limestone is very stiff and clayey and 2 or 3 ft. thick over most of the reservoir site. Below this layer is a zone in which lumps of limestone are found in a clayey matrix, the matrix becoming less and less conspicuous with depth. The lower part of this zone grades into the unaltered bedrock. Bedrock is found at the dam site at a depth of about 12 m. except toward the middle where it is as much as 25 meters.

Some 80 sinkholes have been found within the area to be flooded, ranging in diameter from about 30 cm. to a maximum of 5 m. They have all been tested by pouring in water colored with analine and found to have outlets above the present river level.

The conditions considered favorable for the development of a reservoir at this site are summarized as follows: (1) The clay content of the rock tends to make it self-sealing. (2) The heavy clay soil derived from the decomposition of the limestone clogs the pores and



PRESA-VERTEDERO DEL LAGO DE PATILLAS.
SPILLWAY DAM WITH AUTOMATIC FLASHBOARDS.

cracks of the underlying rock and forms a thick cover that protects it from surface waters. (3) The open sink-holes are all comparatively small and can readily be filled and sealed. All of those thus far recognized have outlets above the present level. (4) Cracks in the exposed rock surfaces are comparatively few and can also be sealed. (5) The high percentage of run-off indicates that there is comparatively little loss of water by underground drainage. (6) The rapidity with which the river rises in response to heavy rains indicates that its basin is relatively watertight and sheds water easily.

Great Precautions Taken. Before the reservoir is filled the land will be cleaned and burned. Precautions will be taken while the water rises to detect all openings, and any that are found will be sealed.

The foundation conditions were thoroughly investigated by means of diamond drill borings and test pits. Bedrock at the dam site consists of relatively soft, grayish-white limestone, interbedded with layers of stiff clay. It is found at depths of from 12 to 25 m. below the surface. The overburden consists largely of clay intermixed with lumps of limestone and of occasional strata of pure clay. A stratum of relatively hard but broken limestone from 3 to 6 m. thick lies immediately above the

grayish limestone described as bedrock. The drill holes show a bed of fine sand which is considered to be a pocket rather than a continuous stratum.

Method of Building Dam. The central portion of the embankment is to consist of a puddle core founded on impervious material and a concrete corewall will be provided to cut off any percolation between the foundation material and puddle core. The bottom of the corewall will be founded on impervious bedrock well below any sand layer and will extend upward into the puddle core a distance varying from 6 m. at the maximum section to 3 m. at the ends of the embankment.

The section of the embankment has been designed to facilitate the grading and compacting of materials by hydraulic methods. The embankment materials are to be loaded by steam shovels into dump carts which will be hauled from the borrow pits to the embankment by steam dinkeys. The track will be maintained along the outer slopes of the embankment where all materials will be dumped. After dumping the embankment material along the two outer slopes, it will be sluiced into place by hydraulic giants. This method of distributing the materials will effect very thorough compacting and uniform grading from the finest material in the puddle core to the coarsest material in the outer slopes.

UNO DE LOS SALTOS CERCA DE COMERÍO.
COMERÍO FALLS—ONE OF THE ISLAND'S MANY SOURCES OF HYDRAULIC POWER.

The material available for the embankment consists of clay intermixed with lumps of limestone found near the dam site. Material excavated from the spillway channel will also be used. The percentages of clay vary from 30 to 60 per cent. Material will be selected from the borrow pits so as to keep the amount of clay between 30 and 45 per cent.

A tunnel 6 m. square will be provided in the right abutment for diverting the river during construction. The material excavated from the tunnel and portal cuts will be deposited in the outer toes of the embankment to serve as cof-

ferdams for diverting the river and for unwatering the puddle core and corewall trenches.

The diversion tunnel will be utilized after completion of the dam as an outlet to the canal. It will be plugged by a concrete bulkhead wall near the inlet, and immediately downstream from it a concrete octagonal gate tower will be built over the tunnel. Two sluice gates will be provided at the base of the tower and a third one at the same level as the canal intake, which is 16 ft. above the base of the tower. The tunnel will also be plugged near its outlet with a bulkhead wall provided with a sluice gate. Immediately upstream from this bulkhead a vertical uptake shaft will connect the tunnel to the diversion canal.

At the left end of the embankment will be provided a spillway channel controlled by a low concrete weir 75 m. long. The spillway is designed for a maximum run-off of 1,100 sec.-ft. per square mile of drainage area, at which rate the maximum depth of water that will pass over the spillway is estimated at 3.75 m. The freeboard of embankment will be then 2.25 m. The spillway channel will be left unlined, although on account of the soft nature of the rock, it seems probable that ultimately it will have to be lined.

Diversion Canal. Types of construction in the diversion canal include the following:

Unlined canal	8,000 m.
Lined canal	4,000 m.
Bench flume	2,100 m.
Tunnel (24 in number)	2,260 m.
Trestle flume	367 m.
Siphon	251 m.

The construction of the canal will be rendered difficult by the inaccessibility of portions of it, and by the fact that water will have to be transported considerable distances. In order that material may be transported along the canal it will be necessary to excavate first a bench along the same on which a narrow-gage track may be laid, and to open most of the tunnels so that the track may be laid through them. Concrete aggregate will be made along the canal as required by a portable rock-crushing and sand-making plant. Concrete work will be started from the center of the inaccessible section toward both ends removing the track as sections of the canal are completed.

The canal will be of 150-sec. ft. capacity, and the slopes will be 0.0006 for canal and bench flume and 0.002 for tunnel, siphon and trestle flume. In fixing upon the initial grade and canal slopes the additional cost of a higher dam has been balanced against the value of the additional irrigable area and power development obtained.

Distribution System. The project lands consist largely of uneven, rolling country, with many isolated hills and depressions or potholes through which the surface waters drain. However, there are some comparatively large areas of fairly uniform land. Topographic surveys have recently been made by the U. S. Geological Survey of about 32,000 acres, half of which has been classified as good irrigable land. Due to the uneven nature of the ground the distribution system will require a large amount of canal lining, flume, siphon and also a large number of drops, culverts, turnouts and measuring structures. In this connection careful consideration is being given to the use of precast concrete for these structures.

Financed by the Insular Government. It is proposed to do all work by administration forces. The project, which is estimated to cost about $3,325,000, will be financed and constructed by the Government of Porto Rico. Construction work will not be started until the final designs and reports have been approved by the Legislature of Porto Rico.

Approved by the U. S. Reclamation Service. A board of engineers from the U. S. Reclamation Service composed of F. E. Weymouth and J. L. Savage, recently visited the site of the proposed irrigation works. After a thorough examination of the plans and reports concerning the project, this board of engineers submitted a report to the Governor of Porto Rico favorable to its construction.