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WITH A DISCUSSION ON CHEMICAL CHARACTERISTICS
OF THE SOILS OF LAGUNA PROVINCE

BY

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SOIL SURVEY OF LAGUNA PROVINCE

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DESCRIPTION OF THE AREA

Laguna Province hugs the coast of the southern half of Laguna de Bay in the southwestern volcanic region of Luzon (fig. 1). It is bounded on the west by Cavite Province, on the south by Batangas and Quezon Provinces, on the east by Quezon Province, and on the north by the Laguna de Bay and Rizal Province. Sta. Cruz, the capital of the province, is ninety-eight kilometers by overland route to Manila. The area of the province is 187,000 hectares, classified into land features as given in Table 1.

TABLE 1.—*The approximate areas of the actual soil cover of the Province of Laguna as of December 31, 1937.*[a]

Kind of land	Area in hectares	Percentage
Commercial forest	17,860.00	9.55
Non-commercial forest	20,440.00	10.93
Open land	42,260.00	22.60
Cultivated land	100,600.00	53.80
Fresh water marsh	5,840.00	5.12
Total	187,000.00	100.00

[a] Tamesis, Florencio. Forest Resources of the Philippines. Proceedings of the Sixth Pacific Science Congress of the Pacific Association, 1939. 4 (1940) 804.

Relief.—The province is rugged in its physical features. The relief ranges from level to hilly and mountainous. All along the Laguna de Bay is a narrow piedmont plain which varies in width from two to twenty miles. The greater portion of the eastern, southern, and western parts of the province is a belt of hills and mountains (fig. 2). The mountains in the eastern section belong to the Sierra Madre ranges. The more prominent mountain peaks in the province are Mt. Sungay (752 meters), Mt. Makiling (1,144 meters), Mt. Banahao (2,188 meters), and Mt. San Cristobal (1,494 meters). Mt. Makiling was once an active volcano as indicated by the presence of solfataras along its slopes, cinder cones near its base, and thermal springs along the shores of Laguna de Bay.

Between San Pablo City and the town of Rizal are several crater lakes, the larger ones being Lake Sampaloc, Lake Palacpaquen, and Lake Calibato.

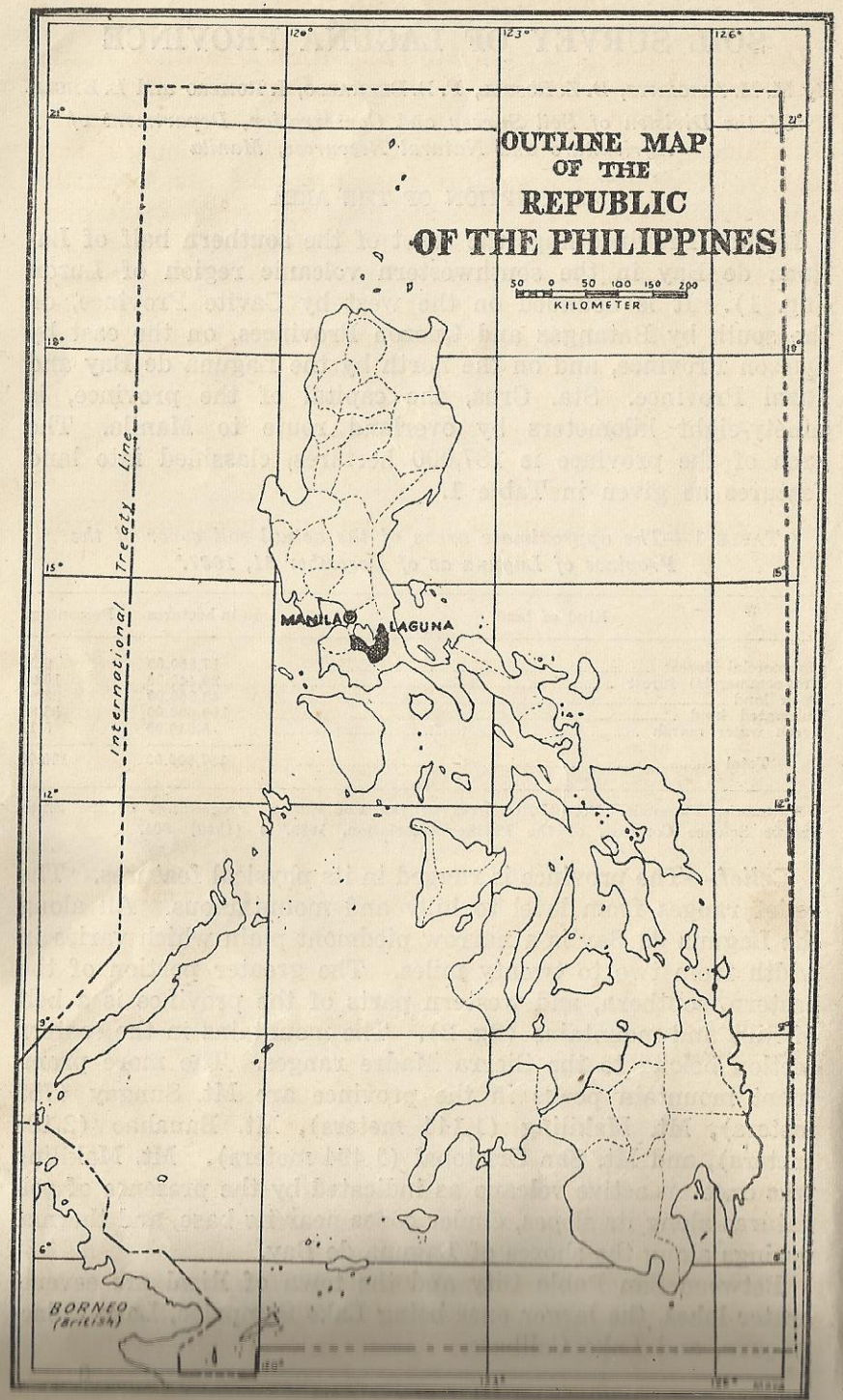

FIG. 1.

Drainage.—Except for the San Pablo-Rizal area which drains southward, the province drains into the Laguna de Bay. Numerous rivers and streams, which have their headwaters in the mountainous regions, cut through the province draining it adequately. The bigger rivers are Pagsanjan and Sta. Cruz, the former being navigable to rafts and bancas throughout the year.

Vegetation.—Primary forest cover the higher slopes and summits of the mountains in the eastern section of the province and the prominent mountain peaks. The lower slopes of these mountains and the hilly and rolling areas in the south and west are covered by coconuts and second-growth forests. The plains and undulating areas are devoted to cultivated crops, while the swamps and marshes along the lake abound in *dapdap, balanggot,* venus, water lilies and other hydrophytic plants of minor importance.

The common wood species of commercial importance found in the primary forests are listed below.

Common name	Scientific name
1. Akle	*Albizzia acle* (Blanco) Merr. (Leguminosæ).
2. Akleng-parang	*Albizzia procera* (Roxb.) Benth. (Leguminosæ).
3. Almon	*Shorea almon* Foxw. (Dipterocarpaceæ).
4. Apitong	*Dipterocarpus grandiflorus* Blanco (Dipterocarpaceæ).
5. Dalingdingan	*Hopea foxworthyi* Elm. (Dipterocarpaceæ).
6. Ipil	*Intsia bijuga* (Colebr.) O. Kuntze. (Leguminosæ).
7. Mayapis	*Shorea squamata* (Turcz.) Dyer (Dipterocarpaceæ).
8. Narra	*Pterocarpus indicus* Willd. (Leguminosæ).
9. Palosapis	*Anisoptera thurifera* (Blanco) Blume (Dipterocarpaceæ).
10. Red lauan	*Shorea negrosensis* Foxw. (Dipterocarpaceæ).
11. Tanĝile	*Shorea polysperma* (Blanco) Merr. (Dipterocarpaceæ).
12. White lauan	*Pentacme contorta* (Vid.) Merr. & Rolfe (Dipterocarpaceæ).

The second-growth forests consist of different species of soft wood, ipil-ipil, rattan, and buho, a species of bamboo adapted for sawali-making.

There are no extensive areas of open grasslands in the province suited for grazing and pasture purposes.

Organization and population.—When the Spaniards came to the region around the Laguna de Bay in 1571, they found several well-established centers of population. The towns of Bay, Pila, and Pangil were the most thickly-populated settlements. As

originally constituted, Laguna Province embraced the territory bounded on the north by Manila and Nueva Ecija Province; on the east by the Pacific Ocean; on the south by Tayabas and Batangas Provinces; and on the west by Cavite Province. The first capital of the province was the town of Bay. In 1688 the seat of the provincial government was transferred to Pagsanjan, and later in 1858 to Sta. Cruz, the present capital. In 1853, Laguna lost the greater part of the territory north of the Laguna de Bay to the then newly created district of Morong. In 1858, however, the province acquired from Nueva Ecija the district of Infanta, and in 1883 the town of San Pablo was acquired from Batangas Province.

At the time of the survey, twenty-nine municipalities comprised the province.

There has been a steady increase in the population of the province as shown by the following figures:

Year	Population
1903	148,606
1918	195,546
1938	279,505

Laguna is the birthplace of Dr. Jose Rizal, the Philippines' best known martyr and patriot.

Transportation.—According to the census of 1938, Laguna has 241.1 kilometers of first-class roads, 56.6 kilometers of second-class roads, 11.7 kilometers of third-class roads, and 14.8 kilometers of trails. This network of roads makes accessible all the towns and bigger barrios from the capital of the province.

The Laguna-Tayabas Bus Company and the Batangas Transportation Company, together with many small and individual private operators, provide adequate means of vehicular transportation for the people in this province. Transportation facilities to and from the surrounding provinces and Manila are available throughout the day.

Other cultural features.—There are public elementary schools in all the municipalities. Primary schools are found in the bigger barrios. A public high school is maintained by the Bureau of Education in Sta. Cruz. Privately owned secondary schools are found in San Pablo, Pakil, Pagsanjan, Calamba, Cabuyao, Biñan, and Sta. Rosa. At the foot of Mt. Makiling are located the College of Agriculture, the School of Forestry,

and a rural high school, all under the University of the Philippines.

A Roman Catholic church is found in every town, where a majority of the people are Roman Catholics. Protestant, Aglipayan and Church of Christ churches are also found in some towns though with fewer adherents.

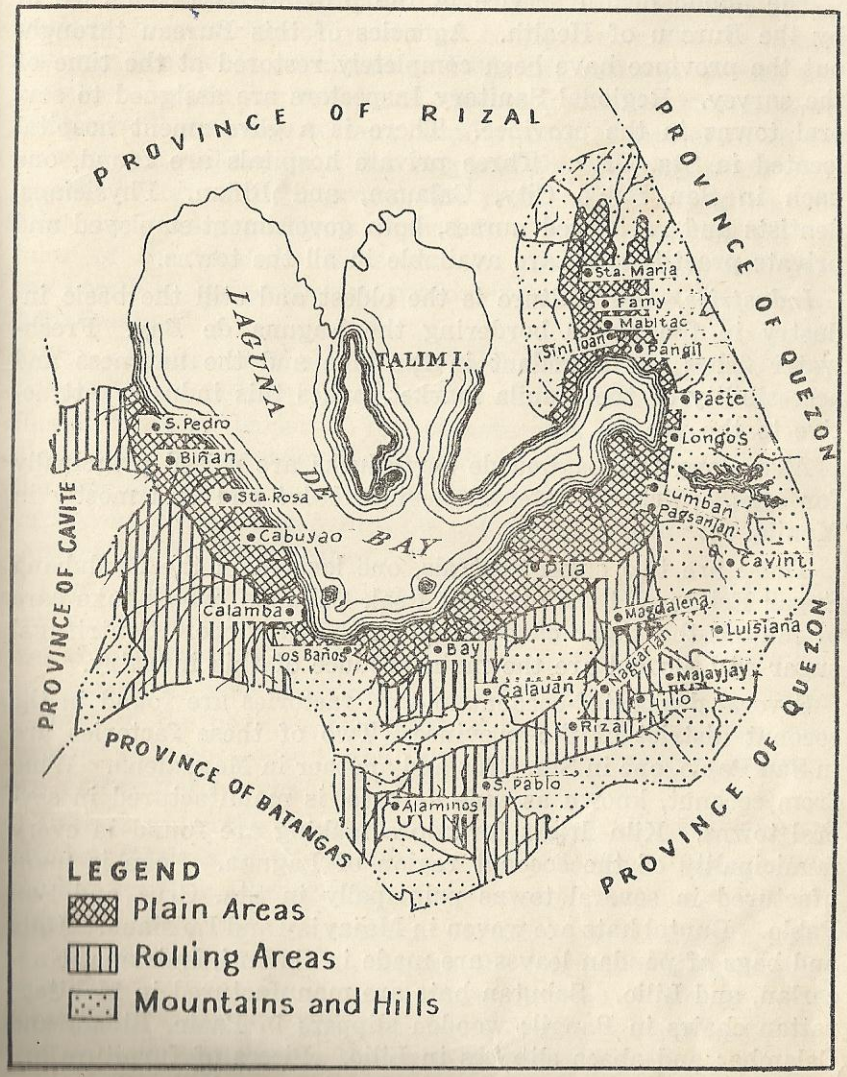

FIG. 2. Sketch map of Laguna Province showing general topography and drainage

Postal and telegraphic service is available in all the towns. Mail is received and dispatched therein every day, except Sundays. The Manila Railroad Company maintains commercial telegraphic lines connecting all railroad stations. At the time of the survey, there was no telephone service available in the province.

The public health service in the province is taken care of by the Bureau of Health. Agencies of this Bureau throughout the province have been completely restored at the time of the survey. Regional Sanitary Inspectors are assigned to several towns in the province. There is a government hospital located in Sta. Cruz. Three private hospitals are found, one each in San Pablo City, Calauan, and Biñan. Physicians, dentists and registered nurses, both government-employed and private practitioners, are available in all the towns.

Industries.—Agriculture is the oldest and still the basic industry in the towns bordering the Laguna de Bay. Freshwater fishes are abundant in the lake and the nearness and accessibility of the Manila market makes this industry attractive to the people.

Also along the Laguna de Bay, ducks are raised principally for eggs, which are later made into *balut* and sold mostly in Manila.

There are two sugar centrals, one located in the Canlubang Sugar Estate and the other in Real, Calamba, which take care of milling the sugar cane raised in the province. Centrifugal sugar and alcohol are the main produce of this industry.

Several desiccated-coconut and oil factories are found in the coconut district of the province. Two of these factories are in San Pablo, one in Sta. Cruz and another in Magdalena. Wine from coconut, known as *vino de coco,* is manufactured in several towns. Kiln driers for copra making are found in every municipality of the coconut region of Laguna. Soap is manufactured in several towns principally in Sta. Cruz and San Pablo. Buntal hats are woven in Majayjay and Luisiana. Hats and bags of pandan leaves are made in Cavinti, Luisiana, Nagcarlan, and Lilio. Sabutan hats are manufactured in Mabitac; rattan chairs in Pangil; wooden slippers in Paete, Biñan, and Calamba; and abaca slippers in Lilio. Pieces of furniture are made in Paete; crude pottery in Lumban; and glazed pottery in San Pedro Tunasan. Mineral water is bottled in Los Baños, Pansol, Pagsanjan, and Magdalena. There is a stone quarry in Los Baños, which supplies crushed stone for the surrounding provinces and Manila.

CLIMATE

Climate plays an important rôle both in soil formation and in the production of agricultural crops. Soil development, especially in geographically limited contiguous areas, is almost entirely dependent on climate. Different rocks or parent materials under similar relief and subject to similar biological activities will give rise to very similar soils, if subjected to the same climatic elements. The length of the cropping season, the variety of crops to be grown, the problems of irrigation, and other husbandry problems depend to a wide extent on the climate of the locality. Subsequently, the industries and even the health of the people are profoundly affected by the prevailing climate.

The climate of the Philippines is characterized by high temperature and heavy precipitation and is called tropical rainforest, monsoon variety. The climate of a province is a subdivision of this broader category and is classified according to the type of rainfall distribution during the year. Temperature variations within a province do not play a significant rôle in this method of classification.

Laguna falls under the first type of rainful (fig. 3). There are two pronounced seasons—dry from December to June and wet from June to December. The heaviest rains fall in June, July, August, and September. The dry season of the open country of the northwestern part of the province is more pronounced than the coconut and forested regions of the southeastern and eastern areas.

Table 2 gives the monthly average rainfall for the different weather stations in the province. Table 2*a* gives the monthly average number of rainy days for the same stations.

Relative humidity and seasonal variations in temperature are similar to those of Manila, though the temperature in Laguna especially in the elevated areas is generally lower than the temperature in Manila. The months of October, November, December, and January are the coolest during the year.

Destructive typhoons and floods are very rare in Laguna due to the protection afforded by the mountains in the province.

AGRICULTURE

Agriculture is the basic pursuit of the people in Laguna even long before the arrival of the Spaniards in the Philippines. The soils bordering the Laguna de Bay was the first to be cul-

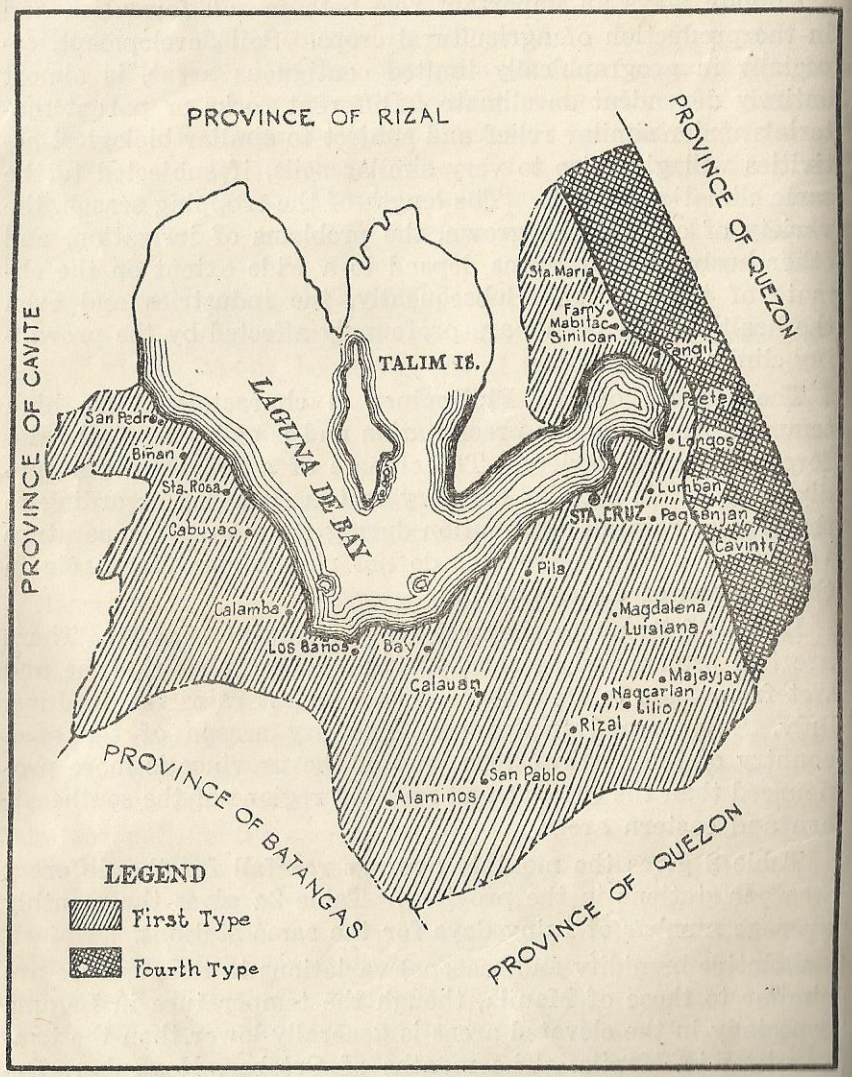

FIG. 3. Sketch map of Laguna Province showing the types of rainfall.

TABLE 2.—*Average rainfall in millimeters in different towns of Laguna Province*

Station	Years of observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Biñan	1903–1904	7.5	18.0	0.0	9.0	62.1	294.0	280.2	125.2	148.6	132.1	46.0	175.3	1298.0
Cantilberg	1916–1933	46.1	22.3	22.2	37.6	209.9	276.8	369.4	423.0	325.5	228.4	210.6	96.2	2268.0
San Antonio	1904–1910	190.0	106.5	122.9	107.4	170.4	195.1	275.6	267.6	362.8	355.4	380.6	338.5	2872.8
San Pablo	1925–1933	57.7	32.1	17.2	41.4	193.6	226.3	353.9	365.1	397.5	251.2	231.4	129.6	2297.0
Santa Cruz	1910–1933	50.2	31.1	30.3	32.2	150.0	211.1	282.7	309.1	274.7	244.5	244.9	138.8	1999.8
Siniloan	1928–1932	74.5	45.0	20.0	65.3	229.0	239.5	301.3	352.4	369.8	245.2	321.0	194.6	2457.6

[a] Compiled from Rainfall of the Philippines, Philippine Weather Bureau (1935).

TABLE 2a.—*Average number of rainy days in different towns of Laguna Province* [a]

Station	Years of observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Biñan	1903–1904	4.5	2.0	0.0	3.0	4.5	14.0	18.0	8.0	13.0	15.0	10.0	15.0	107.0
Cantilberg	1916–1933	8.0	5.8	5.9	4.6	13.5	18.7	20.9	19.7	20.2	17.9	16.4	12.8	165.0
San Antonio	1904–1910	18.2	9.5	12.7	8.2	14.2	16.0	17.0	19.3	19.2	19.0	21.8	23.2	196.3
San Pablo	1925–1933	10.4	7.0	4.8	7.2	14.2	18.9	24.4	18.5	20.1	18.8	18.2	14.4	176.9
Santa Cruz	1910–1933	11.1	7.3	6.5	6.3	11.7	17.6	20.7	19.6	20.3	19.3	18.6	15.8	175.3
Siniloan	1928–1932	13.2	8.6	6.2	8.8	14.4	16.8	20.4	17.2	18.8	18.2	21.2	19.8	183.6

[a] Compiled from Rainfall of the Philippines, Philippine Weather Bureau (1935).

tivated for crop raising, but as the population increased the people moved inland and new sites were developed.

Diversified farming is practiced in the province, with rice, coconut, corn, sugar cane, camote, lanzones and vegetables as the principal crops. Eighty-four per cent of the farm area of the province, representing 84,520.47 hectares, was under cultivation in 1939.

Notable progress in agriculture was attained with the establishment of the College of Agriculture, University of the Philippines, in Los Baños in 1908. Through its researches and demonstrations this institution has influenced agricultural practices in the province towards improvement and modernization.

Table 3 gives the hectarage, production and value of produce in 1939 of the ten leading agricultural crops in Laguna.

CROPS

Coconut.—Coconuts thrive best in light to heavy textured soils like the Lipa loam and Luisiana clay loam types. The coconut plantations in Laguna are found mostly in the upland areas. Nine and nine-tenths per cent of the total number of coconut trees grown in the Philippines are found in this province.

Coconut is the most important crop in Laguna based on the area devoted to its culture, but in the value of produce it is second only to rice. In 1939 there were 7,171,261 coconut trees in the province, of which 5,698,976 were of bearing age, yield-

TABLE 3.—*Area and value of produce of the ten leading crops of Laguna Province* [a]

Crop	Area cultivated in hectares	Production	Value in pesos
1. Coconut	49,863.96	185,805,656 nuts	1,639,232
2. Palay	30,406.71	757,996 cavans	2,153,137
3. Sugar cane	6,887.15	716,495 piculs of centrifugal sugar [b]	
		2,882,953 panochas	4,347,056
		527,903 stalks	
4. Corn	2,003.67	17,410 cavans	42,631
5. Pineapple	257.00	696,426 fruits	53,154
6. Tomatoes	191.39	295,894 kilos	16,102
7. Gabi	173.67	603,879 kilos	23,436
8. Camote	171.70	455,972 kilos	12,800
9. Banana		582,881 bunches	150,730
10. Lanzones		1,010,597 kilos	165,573
Total of the ten leading crops [c]	89,947.25		4,304,881
Total area cultivated for all crops	84,520.47		4,699,411

[a] Data from the Census of the Philippines, 1939 (Agriculture) except the figures on the production and value of centrifugal sugar, which were obtained from Canlubang Sugar Estate and Central El Real, Calamba, Laguna.
[b] Value and production of muscovado sugar not included; negligible.
[c] Total area of the ten leading crops is greater than the cultivated area of the province, because more than one crop is grown on the same area.

ing 185,805,656 nuts valued at ₱1,639,232. The five leading towns in coconut production with the area planted are: (1) San Pablo, 10,079.55 hectares; (2) Nagcarlan, 5,363.60 hectares; (3) Cavinti, 4,211.86 hectares; (4) Majayjay, 3,291.55 hectares; and (5) Alaminos, 2,850.71 hectares.

The present great demand the world over for vegetable oil with the attendant high prices is the cause of the current prosperity in the coconut-producing regions.

Rice.—Rice is second to coconut in hectarage and next to sugar in value. The total area planted to rice in 1938 was 30,406.71 hectares, which gave a produce of 757,996 cavans of palay valued at 2,153,137 pesos. The five leading producing towns with corresponding hectarage are as follows: (1) Calamba, 4,262.59 hectares; (2) Sta. Rosa, 3,944.38 hectares; (3) Calauan, 2,188.15 hectares; (4) Biñan, 2,094.96 hectares; and (5) Cabuyao, 1,773.21 hectares.

The lowland rice varieties commonly grown in this province are Binangkero, Macan, Ramelon, Quezon rice, Inadhika, Guinangang, Elon-elon, Raminad, and Seraup Kechil. Most of these rice varieties mature in 150 to 190 days. The average yield per hectare of lowland rice is 40 to 50 cavans of palay.

The short-maturing rice varieties which are used for upland culture are Inintiw, Kinastila, Kinandang puti, Pinursigue, Pinulot, and Sinampiro. These varieties are drought-resistant and mature in from 100 to 135 days. The average yield in upland rice culture, which includes kaingin, is from 15 to 20 cavans of palay per hectare.

About 50 per cent of the areas devoted to rice is irrigated. The use of fertilizers for this crop is very insignificant due to comparatively high yields obtained without fertilization.

Sugar cane.—This is the third most important crop based on the area planted. Sugar cane is grown on the Lipa loam and Quingua fine sandy loam soil types. The sugar cane plantations are located in Calamba, Cabuyao, Sta. Rosa, Biñan, Calauan, and Calamba. The Canlubang Sugar Estate and the Central El Real, both in Calamba, take care of milling the sugar cane raised in the big plantations. Most of the centrifugal sugar produced is exported to the United States.

Panocha (raw sugar) is manufactured in some municipalities for local consumption.

In 1938 the total area planted to sugar cane was 6,873.15 hectares, which gave a produce of 716,495 piculs of centrifugal sugar, 2,882,953 panochas and 527,803 cane stalks for chewing, all valued at ₱4,347,056.

The sugar cane varieties commonly planted are P.O.J. 2878, 2883, P.S.A. 14, P.S.A. 116, Java 2714 and Alunan.

The average yield of cane is from 40 to 50 tons per hectare.

The use of commercial fertilizers like ammonium sulfate is a common practice in sugar cane culture, especially in the bigger plantations.

Corn.—Corn is grown in almost all farms of the province as a secondary crop. In 1939, 2,009.67 hectares were planted to corn, yielding 17,410 cavans of shelled corn valued at ₱42,651. It is a common practice to harvest this crop as green corn for home consumption.

The common varieties of corn grown in Laguna are the Laguna Yellow Flint and the Laguna White Lagkit.

The five leading corn-producing towns and the area planted are (1) Calamba, 730.90 hectares; (2) Sta. Cruz, 77.44 hectares; (3) Los Baños, 67.57 hectares; (4) San Pablo, 58.84 hectares; and (5) Lumbang, 55.84 hectares.

Pineapple.—Pineapple grows best on light-textured soils. In Laguna most of the pineapples are grown on Lipa loam soil type. In 1938, 257 hectares were devoted to this crop, yielding 696,426 fruits valued at ₱53,154. The leading pineapple-producing towns are Calauan, Siniloan, Cavinti, Los Baños, and Paete. Native and Hawaiian varieties are grown but the latter is preferred.

Tomatoes.—This is the leading vegetable crop of the province. Of secondary importance are eggplant, pechay, mustard, raddish, and cabbage. These vegetables are mostly grown on Quingua fine sandy loam and Marikina silt loam soil types. In 1938, 191.39 hectares were planted to tomatoes, with a production of 295,894 kilos valued at ₱16,102. The five leading towns in the production of tomatoes are Nagcarlan, Rizal, Sta. Cruz, Majayjay, and Biñan.

Gabi.—This crop thrives best on light soils like the Lipa loam, Quingua fine sandy loam and Marikina silt loam types, where internal drainage is adequate. In 1938 the area devoted to this crop was 173.67 hectares for the whole province, yielding 603,879 kilos of gabi valued at ₱23,436. This crop is raised mostly in Calamba, Longos, Nagcarlan, San Pablo, and Rizal.

Camote.—This crop like gabi prefers light soil, though it can be also grown on medium to heavy soils. In 1938, 171.70 hectares were devoted to this crop, with a production of 455,972 kilos of tubers valued at ₱12,800. Sta. Maria, Calamba, Nagcarlan, Longos, and Luisiana produce most of the camote in Laguna.

Bananas.—This plant grows best on newly opened lands with good drainage though it is planted and will grow almost anywhere, in backyards, farm boundaries, hillsides and foot hills. The common varieties grown in the province are Latundan, Lakatan, Bungulan, and Saba. In 1938 the banana produce in Laguna was 582,881 bunches, valued at ₱150,730. Calamba, Mabitac, Sta. Maria, Los Baños, and Nagcarlan are the leading towns in banana production.

Lanzones.—This is the most important fruit crop of the province. Lanzon trees grow well in cool, humid regions with well-drained soils. The Paete clay loam, Luisiana clay loam, and Lipa loam soil types in Laguna are very well suited for this plant. As this fruit tree loves shade, it is usually planted in between coconut trees. In 1938, 1,010,597 kilos of fruits, valued at ₱165,573, were produced in Laguna. The towns leading in the production of lanzones are San Pablo, Nagcarlan, Paete, Pakil, and Lilio. Paete lanzones are the best in the market.

AGRICULTURAL PRACTICES

Agricultural practices in Laguna offer a pattern in contrast. Whereas modern and up-to-date methods of farming are taught in the College of Agriculture at Los Baños and practiced to a liberal extent in the Canlubang Sugar Estate, the greater portion of the farming population still adhere to the centuries-old practices where the plow is the principal implement for tillage and the carabao the main source of power. Except in the sugar cane plantations, maintenance and improvement of soil fertility through the use of fertilizers and the adoption of soil-conserving practices, like green-manuring, crop rotation, and cover-cropping is not observed, due mainly to ignorance and an instinctive apathy toward change. Of late, however, a growing awareness on the part of farmers that things can be improved by adopting modern technics has been noticeable.

Clean culture is practiced in the growing of most annual crops. The practice of planting rice in puddles to impound water has incidentally reduced the losses of soil through erosion to the minimum. In sugar cane culture, however, especially since the crop is usually planted in rolling areas and in furrows, soil-conserving measures are imperative. The Canlubang Sugar Estate is now fully cognizant of this need and has initiated a program to combat soil losses by adopting correct farming methods.

Chemical fertilizers are used only in the large sugar cane plantations. Ammonium sulfate at the rate of 250 kilos per hectare has been used successfully by the Canlubang Sugar Estate in sugar cane fields. Sulfate of ammonia has also been used successfully in the Hacienda Calauan to fertilize pineapples. For rice, coconut, and other crops, however, there is no instance of fertilizer application, except in the experimental lots of the College of Agriculture.

Inter-cropping and catch-cropping are common practices especially in the rolling areas.

In places where irrigation water is available, and this is true in about 50 per cent of the rice growing areas, two rice crops a year are raised.

LIVESTOCK AND LIVESTOCK PRODUCTS

The livestock population in Laguna in 1938 as reported and classified in the Philippines Census of 1939 is given in Table 5. The most important animals are the carabaos, the cattle, and the horses. The carabao is used on the farm as a beast of burden and together with the cattle as sources of milk. Horses are used for pulling *calesas* and *caretelas*. The raising of hogs is encouraged by the abundance of feeds, especially in the coconut and rice-producing areas. Chicken and ducks are the principal poultry products. The sale of eggs from these two fowls provide the farmers with cash income practically all the year round.

The livestock population of Laguna suffered very much during the Japanese occupation. It is estimated that hardly 30 per cent of the prewar livestock in the province has survived. It will take years to restore this industry to its prewar level.

TABLE 4.—*Showing the kind, number, and value of livestock in Laguna Province, 1939*

Kind of livestock	Number	Value (in pesos)
Carabaos	32,539	1,307,175
Cattle	8,757	210,708
Buffaloes	16	1,200
Horses	8,129	202,991
Sheep	65	486
Goats	1,277	3,881
Hogs	42,157	426,961
Chicken	311,583	153,481
Ducks	66,824	37,212
Turkeys	3,620	9,337
Pigeons	2,028	992
Geese	1,207	1,588
Guinea fowls	197	132
Total	478,399	2,356,144

LAND USE

Laguna has an agricultural area of 100,100.47 hectares, classified according to use as given in Table 5.

TABLE 5.—*Land types of Laguna Province classified according to use, 1939* [a]

Kinds of land	Area in hectares	Percentage
Cultivated land	84,520.17	84.40
Idle land	8,660.58	8.70
Pasture land	1,236.49	1.23
Forest land	3,458.22	3.45
Other land	2,225.01	2.22
Total farm area of Laguna Province	100,100.47 [b]	100.00

[a] Data from the Census of the Philippines: Agriculture, 1939.
[b] These data correspond to "Cultivated land" as given in Table 1.

Cultivated land includes areas devoted to the raising of agricultural crops, including coconut trees and lanzones. Idle land is suitable for crop growing but is not so utilized because of some limitations, like absence of irrigation. Pasture land is exclusively used for pasture. Cultivated land used for pasture after harvest is not included in this category. Forest land is made up of forested areas within farm areas. Other lands include building lots, roads, wastelands, and other types not embraced by any of the other categories.

FARM TENURE

Farmers or farm operators are classified in the Philippines Census of 1939 into four classes; namely, owners, part owners, tenants, and farm managers.

Owners are farm operators who own all the land they work.

Part owners are farm operators who own part, and rent or lease from others the other part of the land they work.

Managers are farm operators who supervise the operation of the farm of landowners, receiving wages or salaries or part of the crops produced for their services.

Tenants are farm operators who rent or lease from others all the land they work. Tenants are subdivided into: (1) Share tenants—farm operators who rent the land they work and pay the rent by sharing the crop or crops grown with the owner; (2) cash tenants—farm operators who rent the land they work and pay a definite rent either in cash or produce; (3) share-cash-tenants—farm operators who rent all the land they work and share the harvest with the owner in addition to paying rental in cash.

In 1939 there were 25,720 farmers in Laguna. Thirty-seven and thirty-one hundredths per cent of this number owned their farms; 22.43 per cent were part owners; 39 per cent share tenants; 0.77 per cent share-cash-tenants; 0.49 per cent cash tenants; and 0.03 per cent farm managers.

Of the total farm area in Laguna, 32.16 per cent is farmed by owners; 24.72 per cent by part owners; 40.16 per cent by share tenants; 0.81 per cent by share-cash-tenants; 0.31 per cent by cash tenants; and 1.83 per cent are operated by farm managers.

FARM INVESTMENT

The Census of the Philippines for 1939 lists the farm equipment available in Laguna in 1938 as follows:

Kind of equipment	Number of equipment	Value in pesos
Plows	17,228	
Harrows	12,779	₱353,909.00
Carts	2,145	
Sleds	6,317	

As a consequence of the war much of these equipment was destroyed and at the time of this survey the farmers were badly in need of farm implements.

TYPES OF FARMS

The farms in Laguna are classified as given in Table 7.

TABLE 7.—*Number of farms by type in Laguna Province*

Number	Types of farms	Number of farms	Percentage
1	Coconut	13,765	53.510
2	Palay	8,417	32,720
3	Sugar cane	1,278	4.990
4	Fruits	519	2.010
5	Corn	192	0.740
6	Vegetables	162	0.630
7	Tobacco	1	0.002
8	Palay-Tobacco	1	0.002
9	Abaca	1	0.002
10	Livestock	1	0.002
11	Poultry	1	0.002
12	Other farms	1,388	5.790
	Total	25,720	100.00

1. Coconut farms are farms on which 50 per cent or more of the cultivated land was planted to coconuts.

2. Palay farms are farms on which the area planted to lowland and upland palay was equal to 50 per cent or more of the area of the cultivated land.

3. Sugar cane farms are farms on which the area planted to sugar cane was equal to 50 per cent or more of the area of cultivated land.

4. Corn farms are farms on which the area planted to corn was equal to 50 per cent or more of the area of cultivated land.

5. Fruit farms are farms on which the calculated area planted to fruit trees was equal to 50 per cent or more of the area of cultivated land.

6. Vegetable farms are farms on which the area planted to camotes, mungo, soybeans, tomatoes, sitao, cowpeas, patani, beans, cadios, onions, radishes, eggplants, cabbages, gabi, watermelons, and potatoes was equal to 50 per cent or more of the area of cultivated land.

7. Tobacco farms are farms on which the area planted to tobacco was equal to 50 per cent or more of the area of cultivated land.

8. Palay-tobacco farms are farms on which the area planted to palay was equal to at least 25 per cent and the area planted to tobacco was equal to at least 25 per cent of the area of cultivated land.

9. Abaca farms are farms on which 50 per cent or more of the cultivated land was planted to abaca.

10. Livestock farms are farms which have (1) an area of ten hectares or more; (2) more than ten heads of cattle, horses, goats, and sheep; and (3) less than 20 per cent of the total farm area used for the production of crops, fruits or nuts.

11. Poultry farms are farms on which there were more than 300 chickens or 200 ducks and less than two hectares of cultivated land.

12. Other farms are farms which could not be classified under any of the above eleven groups.

SOIL SURVEY METHODS AND DEFINITIONS

Soil survey deals with the study of soils in their natural habitat. It consists of (1) the determination of the morphological characteristics of soils; (2) the grouping and classification of soil into units according to their characteristics; (3) the delineation of such soils on maps; and (4) the description of their characteristics in relation to agriculture and other activities of man.

The soils, their landscapes and underlying formations, are examined in as many locations as possible. Borings with a soil auger are made, test pits dug, and exposures such as road and railroad cuts studied. An excavation or road cut exposes a series of layers called collectively the soil profile. The hori-

zons of the profile, as well as the color, structure, porosity, consistency and texture, including the organic matter content, roots, gravel and stones, are carefully noted. The reaction of the soil and its contents of lime and salts and other plant food elements are determined either in the field or laboratory. The drainage, both external and internal, and other features, such as relief of the land, climate, natural and artificial cultures, are taken into consideration, and the relationship of the soil and vegetation and many other environmental features are studied.

On the basis of both external and internal characteristics, soils are grouped into classification units, of which the three principal ones are (1) soil series, (2) soil type, and (3) soil phase. When two or more of these mapping units are in such intimate or mixed pattern that they cannot be clearly shown on a soil map, they are mapped or grouped into a (4) complex. Areas of land that have no true soil, such as river beds, coastal beaches, or bare rocky mountainsides, are called (5) miscellaneous land types. Areas that are inaccessible, like mountain and great forest areas, the classification of which is of no agricultural importance for the present, are classified as (6) undifferentiated soils.

A series is a group of soils that have the same genetic horizons, similar important morphological characteristics and similar parent material. It comprises soils having essentially the same general color, structure, consistency, range of relief, natural drainage condition, and other important internal and external characteristics. In the establishment of a series, a geographic name is selected, which is usually the name of the locality or the names of the localities as the case may be, where the soil was first identified. For example, the Paete series was first found and classified in the vicinity of Paete, a town in Laguna Province.

A soil series has one or more soil types, defined according to the texture of the surface soil. The class name, for instance, sand, sandy loam, silt, silt loam, silty clay loam, clay loam, or clay, is added to the series name to form the complete name of the soil. For example, Paete clay loam is a soil type within the Paete series. The soil type, therefore, has the same general characteristics as the soil series, except for the texture of the surface soil. The soil type is the principal unit of mapping. Because of its certain specific characteristics it is usually the unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, differing from the soil type only in some minor features, generally external, that may be of special practical significance. Differences due to relief, stoniness, and extent or degree of erosion are shown as phases. A minor difference in relief may cause a change in agricultural operation or in the kind of machinery to be used. The phase of a type with a slight degree of accelerated erosion may need a fertilizer requirement and other cultural practices different from those of the real soil type. A phase of a type due mainly to degree of erosion, degree of slope, and amount of gravel and stones on the surface are usually segregated on the map if the area can be delineated.

A soil complex is a soil association composed of such intimate mixtures of series, types, or phases that cannot be indicated separately on a map. This is mapped as a unit and called a soil complex. If there are several series in a given area, such as Paete, Luisiana, etc., that are mixed together, the two dominant series bear the name of the complex as Paete-Luisiana complex or Taal-Paete complex. If there is only one dominant constituent, that series or type bears the name of the complex; for example, Paete complex.

Surface and subsoil samples for chemical and physical analyses were collected from each soil type or phase, the number of which was determined by the importance of such soil types or phases. Profile samples were also obtained for further morphological studies of the important soil types.

The soil survey party was composed of three soils men who mapped the area and delineated the various soil types, phases, and miscellaneous land types. All cultural and physical features, such as trails, roads, railroads, barrios, towns, and rivers and lakes; prominent mountains, quarry, reservoir, etc., found in the area are indicated on the soil map.

SOILS OF LAGUNA PROVINCE

Based on their relief, the soils of Laguna are classified into three general land types, namely, (1) soils of the fresh-water marshes, (2) soils of the plains, and (3) soils of the rolling areas, hills, and mountains. These groups of soils have developed different soil profiles as a result of the influence of several factors of soil formation. Based on the genetical and morphological characteristics of the profile and texture of the surface

soil, these land types are further classified into soil series, soil types and phases, as follows:

1. Soils of the fresh-water marshes
   - (*a*) Hydrosols (1)[a]
2. Soils of the plains.
   - (*a*) Quingua fine sandy loam (4).
   - (*b*) Guadalupe clay (18).
   - (*c*) Guadalupe clay adobe (19).
   - (*d*) Marikina silt loam (20).
   - (*e*) Marikina silty clay loam (139).
   - (*f*) Carmona sandy clay loam (39).
   - (*g*) Carmona clay loam (40).
   - (*h*) Calumpang clay loam (52).
   - (*i*) Calumpang clay (147).
   - (*j*) Maligaya clay loam (117).
   - (*k*) Bay clay (146).
3. Soils of the rolling areas, hills and mountains.
   - (*a*) Antipolo clay (26).
   - (*b*) Antipolo clay loam (27).
   - (*c*) Antipolo soils, undifferentiated (28).
   - (*d*) Tagaytay sandy loam (36).
   - (*e*) Taal fine sandy loam (57).
   - (*f*) Lipa loam (62).
   - (*g*) Lipa loam, steep phase (142).
   - (*h*) Luisiana clay loam (140).
   - (*i*) Paete clay loam (141).
   - (*j*) Macolod clay loam (143).
   - (*k*) Macolod clay loam, steep phase (144).
   - (*l*) Macolod soils, undifferentiated (145).
   - (*m*) Mountain soils, undifferentiated (45).

[a] Numbers in parenthesis refer to soil type numbers in the accompanying soil survey map.

The types, phases, and miscellaneous land types are here described, while their location and distribution are shown in the accompanying soil map. Table 12 shows the areas, proportionate extent, and present use of the types, phases, and land types of the province.

SOILS OF THE FRESH-WATER MARSHES

Hydrosols (1).—The coastal regions bordering Laguna de Bay, which is under water almost throughout the year, constitute the hydrosols of Laguna. Areas of this type in Calamba, Los Baños, Bay, Sta. Cruz, Lumbang, Longos, Paete and Mabitac are shown on the map.

In general, the surface water or aqueous horizon of the fresh-water marsh is greenish black to black ranging from 20 centimeters to over a meter deep, this depth being affected by the seasonal changes of the depth of the Laguna de Bay. This

TABLE 12.—*Area, percentage, location, and principal crops grown in each soil type in Laguna Province*[a]

Type number	Soil type	Area (Hectares)	Percentage	Location	Principal crops grown
1	Hydrosol	4,899.4	2.62	Along the lake coast of the towns of Mabitac, Siniloan, Pangil, Pakil, Paete, Sta. Cruz, Pila, Bay, Los Baños, and Calamba.	Hydrophytic plants.
4	Quingua fine sandy loam..	2,038.3	1.09	The barrios of Pulo, Putol, Banlic, Lingga, Mamatid, Calamba; along the rivers of Cabuyao, Biñan, and Sta. Rosa; and along the lake coasts of San Pedro, Biñan, Sta. Rosa, and Cabuyao.	Lowland and upland rice, sugar cane, corn, bananas, sweet potatoes, pineapple, and vegetables.
18	Guadalupe clay	4,768.5	2.55	Both sides along the provincial road from San Pedro southward to barrio Niugan, Cabuyao.	Lowland rice, corn, bananas, sweet potatoes, and vegetables.
19	Guadalupe clay adobe	112.2	0.06	Southwest of San Pedro extending up to the boundaries of Rizal and Cavite.	Upland rice, corn, and vegetables.
20	Marikina silty loam	991.1	0.53	Along the Pagsanjan River north of Lumban and along the mouth of Sta. Cruz River near the lake.	Upland rice, corn, bananas, vegetables, sweet potatoes, and pineapples.
139	Marikina silty clay loam.....	2,337.5	1.25	The barrios of Lingga, Gatid, Labuin, Bubukal, Pila; Eastern Sta. Cruz; and north of the provincial road (Sta. Cruz-Lumban).	Lowland rice, sugar cane, corn, bananas, sweet potatoes, and vegetables.
26	Antipolo clay..	10,621.6	5.68	All the rolling upland and some hilly regions of Mabitac, Sta. Maria, Famy and Siniloan.	Coconuts, upland rice, corn, sweet potatoes, pineapples, bamboos; commercial and noncommercial forests.
27	Antipolo clay loam	187.0	0.10	The barrios of Matiquio, Kabulusan, and Banilan, Mabitac, along the lake.	Upland rice, lowland rice, corn and vegetables.
28	Antipolo soils, undifferentiated	14,791.7	7.91	The inaccessible mountain soils of Sta. Maria, Mabitac, Famy, and Siniloan.	Commercial and noncommercial forests.

[a] The area of each soil type was obtained by the use of a planimeter.

Type number	Soil type	Area (Hectares)	Percentage	Location	Principal crops grown
36	Tagaytay sandy loam	1,196.8	0.64	Barrio Laguerta, Canlubang Sugar Estate, Calamba, extending toward the boundary of Batangas Province.	Diversified farming, coconut, upland rice, corn, sugar cane, bananas, sweet potatoes, and pineapples.
39	Carmona sandy clay loam	2,599.3	1.39	The barrios of Jalang and Canlalay, San Pedro; San Antonio, Zapote, and Lankiwa, southwest of Biñan toward Carmona.	Lowland rice, corn, vegetables, sugar cane, bananas, sweet potatoes.
40	Carmona clay loam	1,252.9	0.67	Southeast of San Pedro, the upstream portions of San Pedro and San Isidro Rivers.	Mangoes, ipil-ipil, sugar cane, upland rice, corn, bananas, sweet potatoes, and pineapples.
45	Mountain soils undifferentiated	28,072.6	15.02	Mts. Sungay, San Cristobal, Banahao, Sierra Madre mountains, and nearby hilly and mountainous regions.	Commercial and noncommercial forests.
52	Calumpang clay loam	597.7	0.31	A portion of Barrio Maahas, Los Baños; Puypuy, Bay; and Maslit, Calauan.	Coconuts, upland rice, vegetables, corn, and sugar cane.
147	Calumpang clay	6,694.6	3.58	Along the lake in the vicinity of the towns of Bay, Pila, and Calauan.	Lowland rice, corn, bananas, vegetables, and sugar cane.
57	Taal fine sandy loam	673.2	0.36	The southern portion of the Canlubang Sugar Estate, Calamba.	Sugar cane, upland rice, coconuts, corn, vegetables, bananas, sweet potatoes and pineapples.
62	Lipa loam	46,179.5	24.69	A large portion of Canlubang Sugar Estate, Philippine Sugar Development Co. at Real, Calamba; along the railroad track from Los Baños to Mabacan; a portion of Calauan; southern areas of Pila, Sta. Cruz; and a large portion of Magdalena, San Pablo, Alaminos, and Rizal.	Generally diversified, coconuts, sugar cane, pineapples, upland rice, avocado, caimito, root crops, and vegetables.
142	Lipa loam, steep phase	56.0	0.03	The Mayondon Point at Los Baños.	Coconut, ipil-ipil.
117	Maligaya clay loam	4,656.3	2.49	All the lowland areas of Sta. Maria, Famy, Mabitac, Siniloan, and Pakil; along the flood plain of San Antonio River.	Lowland rice, corn, sugar cane, vegetables, bananas, sweet potatoes, and pineapples.
140	Luisiana clay loam	27,152.4	14.52	Cavinti, Luisiana Majayjay; southern portions of Lilio and Nagcarlan; and around the foot of Mt. Banahao.	Coconuts, buri palm, pandan, sugar cane, upland rice, corn, bananas, sweet potatoes, pineapples, lanzones, commercial and noncommercial forests.

Type number	Soil type	Area (Hectares)	Percentage	Location	Principal crops grown
141	Paete clay	4,731.1	2.53	The rolling area east of the provincial road from Pagsanjan–Lumban–Longos, Paete, Pakil and Pangil.	Coconut, lanzones, santol, upland rice, corn, bananas, sweet potatoes, pineapples, commercial and noncommercial forests.
143	Macolod clay loam	5,740.0	3.07	The undulating to slightly rolling area around Mt. Makiling, Mt. Calauan; a large area north of Lilio and north and west of Nagcarlan.	Upland rice, sugar cane, corn, sweet potatoes, bananas, coconut, pineapples, and lanzones, second growth forest, and ipil-ipil.
144	Macolod clay loam, steep phase	9,611.8	5.14	The roughly rolling to hilly areas of Mt. Makiling, Mt. Calauan and nearby hills and mountains.	Second growth forests, ipil-ipil, sugar cane, upland rice, corn, bananas, sweet potatoes, pineapples, lanzones, and coconuts.
145	Macolod soils, undifferentiated	5,579.2	2.98	The higher portion of Mt. Makiling which is not suitable to agriculture.	Second-growth forests, commercial and noncommercial.
146	Bay clay	1,477.3	0.79	The strip of land along the lake coasts of Lumban, Longos, Paete, Pakil, Pangil, Siniloan, and Mabitac.	Lowland rice.

horizon is the most important medium for the growth of algae and other halophytic plants which are sources of food for fish. The aqueous horizon is underlain by the subaqueous horizon corresponding to the "A" horizon of a normal soil profile. This horizon is of mossy, slimy gray to black silty clay with plenty of undecomposed organic matter. Its depth varies from a mere film to 60 centimeters. The subaqueous horizon is underlain by the subbasal horizon composed of gray slimy clay and sometimes sandy materials with a depth of 15 to 70 centimeters. This horizon corresponds to the "B" horizon of the normal soil profile.

The hydrosols of Laguna have no agricultural value, but a portion of this area is devoted to fish culture which is an important source of livelihood of the people living in the coastal areas and mouths of rivers. It has an area of 4,899.4 hectares, or 2.62 per cent of the total area of the province.

SOILS OF THE PLAINS

The plain areas of Laguna are located on a narrow coastal area bordering the bay, extending from the towns of San Pedro

to Calamba, Los Baños to Sta. Cruz, and Sta. Cruz to Mabitac. The soils of these plains are generally heavier in texture than those of the uplands. Profile development of these soils are still in the early stages. The color of the surface soil ranges from black to brown, and the texture grades from clay to clay loam, and sandy to silt loams. The parent materials of these soils are water-laid volcanic tuff and other weathered rock material brought down by the rivers from the uplands. Most of the rocks are volcanic.

The plains of Laguna constitute the rice granary of the province. Wherever irrigation water is available, rice is grown twice a year. The other crops grown are corn, sugar cane, coconuts, root crops, vegetables, bananas and fruit trees. The soil series found in this area are the Quingua, Guadalupe, Marikina, Carmona, Calumpang, Maligaya and Bay. The total area of these series is 27,514.7 hectares, or 14.71 per cent of the province.

Quingua fine sandy loam (4).—This type was first classified and mapped in Bulacan Province. As classified and mapped in Laguna, this type has an area of 2,038.3 hectares and is found along the mouths and banks of Biñan, Sta. Rosa, Cabuyao, San Juan, and San Cristobal Rivers. It is considered one of the most productive soils of the province. A variety of crops, especially vegetables, are grown profitably. This type being a river deposit of sandy to fine sandy material is deep, varying from 60 to 120 centimeters from the surface. The depth varies according to the level of the river flood terraces. The surface soil is typical light brown, sometimes pale brown along the river banks. It is usually loose, very seldom compact except in higher and undisturbed areas. The subsoil is characteristically light brown to brown with heavier material than the surface soil.

The slightly elevated areas with good drainage are planted to sugar cane, upland rice, corn, bananas, sweet potatoes, pineapples, and vegetables of all kinds. A good harvest is always obtained from these crops every year. On the lower river terrace, where the water of the river is diverted to irrigate the land, lowland rice is grown. An average yield of 50 to 60 cavans of palay per hectare is obtained from this type.

Guadalupe clay (18).—This type is the extension of the Guadalupe series mapped and classified in Cavite and Rizal Provinces. As classified and mapped in Laguna, it constitutes the rice lands of San Pedro Tunasan, Biñan, Sta. Rosa and Cabuyao.

Wherever irrigation water is available in areas of this type, two rice crops are grown annually.

A typical profile description of this type is as follows:

Guadalupe clay

Depth of soil cm.	Characteristics
0–30	Very dark-brown to nearly black coarse granular columnar clay. When wet, it is sticky and plastic, and cloddy when dry. Boundary is wavy and clear.
30–50	Lighter in color than the surface soil. Finely granular to columnar when dry and sticky when wet. Spherical tuffaceous concretions present. Boundary is broken and abrupt.
50–110	Tuffaceous rock with concretions. Black clay is present in the crevices of rocks.
110–150	Very dark to black soil leached from the subsoil.
150 below	Tuffaceous material, massive and hard.

The surface soil is very dark-brown to nearly black clay, plastic and sticky when wet. It is coarse and granular to columnar in structure when dry. The subsoil is lighter in color than the surface soil. In some areas limestone concretion is present in both the surface soil and subsoil. The substratum is water-laid tuffaceous material.

In this type, lowland rice is grown. Whenever irrigation water is not available, the rice crops depend upon the rain for water. A few hectares of well-drained land are grown to corn, vegetables, bananas, and sweet potatoes. On areas that are low and poorly drained, zacate grass, a feed for horses, is planted. The late-maturing varieties of rice raised in this area are the Guinangang, Inadhika, Banbang, Elon-elon, Raminad, and Ramai, which give an average yield of from 50 to 60 cavans per hectare.

Guadalupe clay adobe (19).—This is an extension of the type mapped in Cavite Province, occupying a small area of 112.2 hectares. Like the Guadalupe clay, the surface soil is very dark brown to nearly black in color with an average depth of 20 centimeters. The undisturbed soil is hard and compact and bakes easily when dry. The cultivated soil is plastic and sticky when wet, and is coarse granular and cloddy when dry. The upper subsoil is clay, finely granular, sticky when wet, lighter in color than the surface soil, reaching a depth of from 40 to 45 centimeters from the surface. The upper subsoil is underlain with a zone of volcanic tuff material, with crevices filled with dark-colored soil leached from the surface soil by percolating water.

The substratum is a massive volcanic tuff. In highly eroded areas this tuff material is exposed to the surface. The topography of this type which is undulating to rolling is sus-

ceptible to erosion. Erosion in this type of soil can be minimized by terracing, contour tillage operations, and strip cropping. On areas where erosion has already begun, a permanent cover of trees and grasses should be grown, fenced off from animals.

This type is devoted to upland rice, corn and vegetables. Uncultivated areas are used for pasture.

Marikina silt loam (20).—This type was first classified and mapped in the Marikina Valley, Rizal Province. As classified and mapped in Laguna Province, it is found along the mouth and banks of the Pagsanjan and Sta. Cruz Rivers. Generally, this type has good external and internal drainage. The surface soil is light brown, friable and mellow silt loam, with an even distribution of brick-red streaks. Its depths ranges from 20 to 25 centimeters. The subsoil is dark-brown to light gray, granular and friable clay loam. The subsoil down to 80 centimeters deep is separated from the surface soil by a smooth boundary. The substratum is a bed of highly weathered tuffaceous material.

Vegetable crops, such as radish, pechay and mustard, besides corn, sweet potatoes and mungo, grow vigorously in this type of soil. With proper cultural practices this type of soil would be without equal in productivity in the province.

Marikina silty clay loam (139).—A typical profile of this type is described as follows:

Marikina silty clay loam

Depth of soil cm.	Characteristics
0–15	Surface soil, light brown to brown, silty clay loam with brick-red streaks, coarse granular structure, soft and plastic when wet, cracks and becomes hard when dry Depth ranges from 15–20 cm., generally separated from the subsoil by a smooth boundary.
15–40	Subsoil, dark-brown to light gray clay loam, finely granular and very friable. Boundary is smooth.
40–60	Lower subsoil, light brown clay loam with gray mixture, almost compact, but granular, plastic and soft when wet; hard and cracks when dry.
60–below	Light brown clay loam with slight mottling of light gray and brown clay loam; almost compact but friable.

This type covers an area of 2,337.5 hectares, or 1.25 per cent of the area of the province. It constitutes the lowland rice fields of Sta. Cruz and portions of Pila. Its topography is level to undulating.

Rice is the principal crop grown in this soil type. Raminad, Elon-elon, Guinangang, Quezon rice, and Seraup Kechil 36 are the important rice varieties planted. Irrigated rice fields give an average yield of 50 cavans per hectare, while the average yield per hectare of the unirrigated areas is 40 cavans. This yield could be improved through fertilization, or by the addition of organic matter through green manuring.

Carmona sandy clay loam (39).—This soil type is a continuation of the Carmona sandy clay loam described and mapped in Cavite Province. It is undulating to level in topography with an area of 2,599.3 hectares. The irrigated portions in the municipalities of San Pedro, Biñan and Sta. Rosa are devoted to lowland rice, while the unirrigated areas are planted to sugar cane, corn, sweet potatoes, bananas, and vegetables of various kinds.

The surface soil is pale-brown to gray sandy clay loam with plenty of concretions. It is friable when moderately dry, and sticky and plastic when wet. The subsoil is pale-brown to yellowish gray plastic clay when wet, with plenty of dark-brown and reddish-brown concretions. When dry, it is hard and compact. The substratum is highly weathered tuffaceous material. The availability of irrigation water permits the farmers to raise two crops of rice every year.

The rice varieties best adapted to this soil type are Raminad which gives a yield of 40 to 50 cavans per hectare; Ramelon, Quezon and Inadhika, which give from 50 to 60 cavans per hectare. Like the other lowland rice fields in Calamba, Bay and Pila, these lands have been grown to lowland rice year after year.

Carmona clay loam (40).—The surface soil is brown to light grayish-brown clay loam with concretions. The undisturbed soil is hard and compact and cracks considerably during the dry season. The subsoil is light grayish-brown clay with tuffaceous material and concretions. The subsoil is underlain with a massive, highly weathered material.

The profile characteristics of this type are as follows:

Carmona clay loam

Depth of soil cm.	Characteristics
0–30	Surface soil brown to light grayish-brown, clay loam to clay, cloddy and granular with a few concretions. Smooth and clear boundary.
30–55	Subsoil brown to light grayish-brown clay with tuffaceous material and concretions. Smooth and clear boundary.
55–80	Light yellowish-brown to light grayish-brown, highly weathered tuff with concretions.
80–150	Mottled brown, dark-gray clay, cloddy, tuffaceous material.

The topography of this soil type is gently undulating to slightly rolling with drainage from fair to poor. It is grown to upland rice, corn, mangoes, pineapple, bananas, sweet potatoes, and ipil-ipil. The topography of this type is ideal for orchard planting. The upper portions which are idle are used for pasture.

Calumpang clay (147).—A typical profile description of this type is as follows:

Calumpang clay

Depth of soil cm.	Characteristics
0–25	Surface soil brownish-gray, dark-gray to black clay, hard and compact in consistency. When wet, it is sticky and when dry, it cracks and forms into clods which are hard to break. Horizontal boundary is clear and smooth.
25–60	Subsoil mottled, lighter in color and heavier in texture than the surface soil, with waxy and oily character. Boundary is smooth and abrupt.
60–100	Substratum yellowish-brown volcanic tuff material.

This soil type has an area of 6,694.6 hectares, representing the most extensive and one of the best lowland-rice areas of the province. It is level to undulating in topography, consisting of flood plains with wide terraces. Its drainage, however, is poor. Areas of this soil type are located in the municipalities of Calamba, Bay, Calauan and Pila. Two rice crops are grown annually because of the availability of irrigation water during the growing season. Both the medium and late-maturing rice varieties, such as Elon-elon, Raminad, Guinangang, Seraup Kechil, Inadhika, and Apostol, are grown. As high as 80 cavans of palay is obtained on unusually productive and well-managed soils, but the yields range from 50 to 60 cavans per hectare. The average yield per hectare could be raised by the use of fertilizers, addition of organic matter to the soil, thorough preparation of the land, and planting the right variety. In this region, the *dapog* system of seedbed preparation (floating seedbed) is practiced owing to the proximity of rice, fields to streams where irrigation water is available.

Calumpang clay loam (52).—This type has similar profile characteristics as those of the Calumpang clay. The difference is that this type lies on a slightly higher elevation than the Calumpang clay, hence it is fairly well-drained. It is level to undulating in topography. This soil, which is mostly located in the municipality of Bay, is mainly planted to coconut. It occupies an area of 597.7 hectares.

The surface soil is brownish-gray to dark-gray, hard and compact clay loam, ranging in depth from 25 to 35 centimeters. The subsoil is dark-brown, stiff and waxy heavy clay loam to clay. Its depth ranges from 35 to 55 centimeters. The substratum is yellowish-brown volcanic tuff material down to 150 centimeters deep. Aside from coconut, upland rice, corn, and sugar cane, vegetables of various kinds are also grown.

Maligaya clay loam (117).—This type was first mapped and described in Nueva Ecija Province. In Laguna it occupies the lowlands devoted to rice in the towns of Siniloan, Famy, Mabitac, and Sta. Maria. It has an area of 4,656.3 hectares, the third most extensive soil type devoted to lowland rice.

The profile characteristics of this type are as follows:

Maligaya clay loam

Depth of soil cm.	Characteristics
0–25	Surface soil reddish-brown to dark-brown clay loam with reddish-brown to brick-red streaks. When wet, it is sticky and plastic; friable and granular when dry. Concretions are present. Horizontal boundary is smooth and gradual.
25–60	Subsoil brown to pale reddish-brown compact clay loam. When moderately dry, it is friable and granular; heavy and slightly plastic when puddled. Boundary is smooth and gradual.
60–100	Light brown to grayish-brown clay to silty clay, heavy and compact; it is mottled reddish brown and dark gray. Boundary is smooth and gradual.
100–150	Light brown to light reddish-brown, slightly compact silty clay, course and gritty.

This soil type constitutes the valley in the northeastern part of the province within the municipalities of Siniloan, Famy, Mabitac, and Sta. Maria. Its topography is level to nearly flat with an elevation of 150 feet from sea level. In areas that are not flooded during the rainy season, sugar cane, corn, bananas, pineapples, sweet potatoes and various kinds of vegetables are planted.

Rice is the principal crop grown in this soil type. The farmers depend on rain water and streams to irrigate the farms during the rainy season. Only one rice crop is raised a year. The yield of rice ranges from 40 to 60 cavans per hectare.

Bay clay (146).—This type lies below the high water level of the Laguna de Bay and is usually submerged for months during the rainy season. It consists of the accumulation of sediments which have been carried into the bay by streams and washed

over into the present location by wave action. The profile characteristics of this type are as follows:

Bay clay

Depth of soil cm.	Characteristics
0–25	Surface soil dark-brown clay, heavy and sticky clay to clay loam. Horizontal boundary is smooth and gradual.
25–60	Subsoil dark-green to bluish-green, sticky and plastic heavy clay. Boundary is smooth and abrupt.
60–140	Bluish-green to gray sticky clay.
140–150	Coarse to gritty sand.

The topography of this type is flat. It is devoted to rice during the latter part of the rainy season when water from the bay subsides with the approach of the dry season. Land preparation usually begins during the months of November and December and the harvest season during the months of April-May. Due to the yearly deposition of rich alluvial soil from the uplands, a good harvest of rice is obtained from year to year. The yields range from 50 to 60 cavans to as high as 70 cavans per hectare on isolated areas. Among the standard rice varieties raised are Seraup Kechil 36, Elon-elon, Raminad, Macan, San Pedro, and Guinangang.

SOILS OF THE ROLLING AREAS, HILLS AND MOUNTAINS

Laguna Province is generally hilly and mountainous, the uplands constituting about 82.57 per cent of the area of the whole province. These rolling to roughly rolling areas are found on the slopes of Mts. Makiling, Malepunyor, Nagcarlan, Banahao, San Cristobal, and the South Sierra Madre mountain. These ranges vary in width from 3 to 32 kilometers, and in altitude from 100 to 7,000 feet above sea level. The greater portion of this area is uncultivated; the highest portions are covered with virgin forest; the lower portion with second-growth forest and coconut; and the base areas are grown to all kinds of crops and fruit trees found in the province.

Due to relief, drainage ranges from good to excessive. Soil erosion oftentimes becomes serious where adequate means of soil conservation is wanting. The upper slopes of these mountains are composed of basaltic rocks, while the lower slopes are covered with volcanic tuff. This mantle of tuff covers nearly all the areas around the base of the mountains and constitutes the parent material of the soils found therein. Soils of the rolling areas and mountains are generally brown to

dark brown and dark grayish brown to red. The thickness of the surface soils varies from a thin layer to indefinite depth, while the texture grades from loam, sandy loam, clay loam to clay.

The series newly established in this area are Macolod, Luisiana, and Paete. The Paete series is named after the town of Paete where most of the areas of this series were mapped; the Luisiana series, from the town of Luisiana; and the Macolod series, after the same series described by Dorsey in 1903 in Mt. Macolod, Batangas Province. The other soil series found in this area had previously been described and mapped in other provinces by Alicante, et al.; the Taal and Lipa series in Batangas; the Tagaytay series in Cavite; and the Antipolo series in Rizal Province.

Antipolo clay (26).—This type is the extension of the Antipolo series mapped and described in Rizal Province. It constitutes the rolling uplands of the municipalities of Mabitac, Sta. Maria, Famy and Siniloan. The profile description of this type is as follows:

Antipolo clay

Depth of soil cm.	Characteristics
0–25	Light reddish-brown, friable, finely granular clay; slightly compact with spherical tuffaceous concretions. Horizontal boundary is smooth and gradual.
25–55	Dark reddish-brown granular to friable clay. Concretions are present, slightly compact. Boundary is smooth and gradual.
55–85	Reddish-brown granular and friable clay loam, slightly compact. The lower part of this horizon is the beginning of the adobe structure. Boundary is irregular and obscure.
85–120	Zone of highly weathered tuffaceous material. Finely granular, slightly friable clay loam, with concretions present. Boundary is wavy and abrupt.
120–150	Dark reddish-brown clay loam, very friable and coarse granular. Soft concretions are present.

The surface soil is light reddish-brown, friable, slightly compact clay. Spherical tuffaceous concretions are present. The upper subsoil from 25 to 55 centimeters is dark reddish-brown, friable clay and slightly compact. Few concretions are present. The lower subsoil is a zone of highly weathered tuffaceous material. Its average depth varies from 55 to 85 centimeters. The substratum from 120 centimeters is highly weathered material, finely granular and slightly friable. The area of this type is about 10,621.6 hectares.

This type is covered with commercial and noncommercial forests and coconuts. Upland rice on kaingins is grown on the hill sides. Other crops raised are lanzones, corn, pineapple, and root crops. Grass (cogon) and shrubs are common in the open lands on the sides of upland areas.

Antipolo clay loam (27).—This is an extension of the same soil type mapped in Rizal Province. It extends from the Rizal-Laguna boundary on the coastal region to barrio Banilan.

The Antipolo clay loam is a strip of slightly rolling to undulating land located on the shoreline of Laguna de Bay. The surface soil is dark reddish-brown clay loam, finely granular and friable when dry. It is slightly sticky when wet. The characteristics of the subsoil and substratum are similar to those of the clay type. On the rolling areas, basaltic boulders are abundant. Both upland and lowland rice are grown in this soil type.

Antipolo soils, undifferentiated (28).—The area is mountainous and covered with forest, which makes the delineation of the soil boundaries very difficult. Because of the exceedingly steep slopes and rough topography, the land has no agricultural value at present. It covers an area of 14,791.7 hectares, or 7.91 per cent of the area of the province. Generally, the soil of this area is similar to Antipolo clay.

Tagaytay sandy loam (36).—This is the extension of the same soil type classified and mapped in Cavite and Batangas Provinces. In Laguna Province, it is located at the boundary of Batangas and in the rolling uplands of Calamba.

The surface soil to a depth of 12 to 50 centimeters is dark-brown to nearly black, friable and granular sandy loam, with a considerable amount of volcanic sand. The subsoil is dark brown to very dark brown, and varies in texture from clay loam to clay. It is underlain by reddish-brown to yellowish-brown adobe clay. This adobe clay varies in depth, depending on the topography of the area.

Areas of this type are generally planted to coconuts, fruit trees, and vegetables.

Taal fine sandy loam (57).—Like the Tagaytay sandy loam, this type is the extension of the same type classified and mapped in Batangas Province. It consists of light gray, loose, structureless fine sandy loam surface soil, ranging in depth from 30 to 40 centimeters. Below this horizon are several thin layers of volcanic sand, separated by thick horizons of fine sand. In general the surface soil and subsoil are loose and seldom compact.

This type produces good crops of sugar cane every year. It is easily prepared because of its good physical properties. Upland rice and coconuts are generally planted in this type of soil.

Lipa loam (62).—This type represents soils formed from the decomposition and disintegration of the underlying volcanic tuff materials. It is a typical residual soil. The underlying strata of rocks are uniform and deeply weathered. It is generally undulating to rolling in topography, with an altitude ranging from 100 to 500 feet.

The surface soil to an average depth of 30 centimeters is brown to dark-brown, very friable, mellow and loose loam. The subsoil has a darker color and is heavier in texture than the surface soil. The lower subsoil usually consists of highly weathered tuff with tuffaceous gravel and concretions. The subsoil is underlain by tuff, light brown, fine-textured to sandy material.

This soil is easily eroded. Sheet erosion is a common sight in areas left bare, and in places where the relief is roughly rolling. Of the soil types described in the province, Lipa loam has the best physical characteristics. A typical profile of Lipa loam is described as follows:

Lipa Loam

Depth of soil cm.	Characteristics
0–30	Brown to dark-brown, mellow, loose and very friable, fine granular loam. Horizontal boundary is smooth and clear.
30–75	Dark-brown clay loam, friable fine granular tuffaceous material with concretions. Irregular and abrupt boundary.
75–120	Highly weathered tuff with tuffaceous gravels and concretions. Broken and abrupt boundary.
120–150	Tuff, light brown compact fine-textured to sandy material.

This soil type is grown to almost all the major crops found in Laguna. It is devoted to sugar cane in the Canlubang Sugar Estate and Central El Real in Calamba; to pineapple in the Hda. Calauan; to coconut in Magdalena, San Pablo, Alaminos, Rizal, and Canlubang, Calamba; and to upland rice, lanzones, vegetables and fruits trees in other places.

In areas where the topography is not so steep as that of the Canlubang Sugar Estate and Central El Real, farm machinery is used to plow and cultivate the fields. Machinery is usually applied in the cultivation of sugar cane.

Lipa loam, steep phase (142).—As its name indicates, this type is rolling to steep in topography. It is only a minor type

with an area of 56 hectares comprising the Mayondon hill in Los Baños.

The friability and looseness of the surface soil, plus the steepness of the slope, have made it a critical area for sheet and gully erosion. Where the soil is devoid of vegetation, the surface soil has been eroded. Where vegetative cover is available, there remains a thin surface soil. Only stratified rocks are left exposed where erosion is serious. Coconut trees and ipil-ipil are still found growing on the steep slopes, with their roots clinging tenaciously to the last layer of soil left.

LUISIANA SERIES

The Luisiana series resembles the rolling upland soils belonging to the Antipolo, Alaminos and other reddish-brown to red soils which have developed from basaltic rock material. The weathering and decomposition of the parent rock have gone so deep that the resulting soil has developed into indefinite depth. Except for the variation in color, structure, and consistency, the profile from the surface down to the substratum of 200 centimeters or more exhibits a uniformity of texture.

Luisiana clay loam (140).—This type is the second most extensive in the province, occupying an area of 27,152.4 hectares. It constitutes the upland soils of Luisiana, Cavinti, Majayjay and Lilio extending to as far as Lucban, Tayabas. It ranges in altitude from 500 up to over 1,000 feet.

Coconut is the principal crop grown. Copra and coconut oil are the two principal products derived from coconut. Coconut wine and copra meal for hogs and poultry feed are minor products.

Both upland and lowland rice varieties are planted in this region. Inintiw upland rice variety is broadcast on lands between coconut trees or in kaingins. Rice terraces in pockets range in area from 100 square meters to a half-hectare. These rice lands depend on rain water and streams diverted from their courses for irrigation water. Fairly good yields from upland and lowland-rice fields are obtained from year to year.

The internal and external drainage are good. Soil erosion is not much of a problem because the cultivated area is grown to coconut, and cogon grows on the vacant areas. Other crops grown are pandan and buri palms for mat and hat weaving, respectively. The upper parts are covered with forest. Lanzones, bananas, corn, and sugar cane are also grown in this soil type.

The profile characteristics of this soil type are as follows:

Luisiana clay loam

Depth of soil cm.	Characteristics
0–25	Brown to light reddish-brown very friable clay loam to clay; prismatic to columnar in structure when dry, and coarse to granular when wet. When wet, it is sticky and when dry, loose and friable. Horizontal boundary is smooth and obscure.
25–70	Yellowish brown to light reddish-brown friable and mellow clay columnar in structure when dry. A reddish-purple streak is produced when surface soil is cut with a spade or struck with a geologic hammer. It is splotched with light gray, yellowish gray or yellow color. Horizontal boundary is smooth and obscure.
70– and below	Very friable clay, splotched with light gray to yellowish-gray to yellow color.

PAETE SERIES

Paete clay loam (141).—This type comprises the lower slopes of the South Sierra Madre mountain ranges in the vicinity of Pagsanjan, San Juan, Longos, Paete, Pakil, and Pangil. It is hilly to mountainous in topography. A typical profile of the soil type is as follows:

Depth of soil cm.	Characteristics
0–15	Brown to dark-brown slightly granular clay loam with plenty of pebbles, stones and boulders. It is slightly compact, sticky when wet, and loose and friable when dry. Horizontal boundary is irregular and obscure.
15–50	Reddish-brown to brown granular clay loam to clay, sticky when wet, loose and friable when dry; slightly compact. Peebles and stones are present. Boundary is wavy and obscure.
50–90	Brown to reddish-brown clay with big basaltic boulders. Boundary is smooth and clear.
90–150	Weathered andesite and basaltic rocks.

The surface soil is brown to dark-brown, gravelly and slightly friable clay loam, ranging in depth from 15 to 20 centimeters. The surface soil has plenty of basaltic boulders which make the soil loose and structureless. The subsoil is reddish-brown to dark-brown, granular clay loam to clay, sticky and hard when wet, loose and friable when dry. It is slightly compact. Its depth ranges from 15 to 50 centimeters. The substratum is brown and reddish-brown clay with big basaltic boulders.

The whole area is covered with forest vegetation. On the lower slopes, lanzones and santol are planted between rows

of coconuts. Other crops grown are bananas and citrus. This soil type has an area of 4,731.1 hectares.

MACOLOD SERIES

The Macolod series was first classified by Dorsey in 1903 when he surveyed the Batangas area. The soils of this series are similar in many respects to the Ibaan soils. Generally, this series consists of brown tenacious clay loam surface soil containing 10 to 20 per cent of coarse skeleton of fine rounded gravels. In other places this coarse skeleton consists of an admixture of sharp angular gravels composed of hard black volcanic andesite rocks. The subsoil is light reddish-brown, slightly compact and slightly granular clay underlain by weathered andesite rocks.

The topographic features of this series is rolling to hilly and mountainous. Its drainage is good. The vegetation in the hilly and mountainous areas consists of talahib, cogon, shrubs, ipil-ipil and second-growth forest. The cultivated areas are planted to rice, bananas, root crops, sugar cane, corn, lanzones, and coconuts.

Macolod clay loam (*143*).—This type is generally found on the slopes of Mount Makiling and the surrounding hills. Its topography is generally rolling, hilly to mountainous. The profile characteristics of this type are as follows:

Macolod clay loam

Depth of soil cm.	Characteristics
0–15	Dark grayish-brown to brown tenacious clay loam; coarse skeleton of 10 to 20 per cent fine rounded gravels. Black andesite rocks exposed on steep slopes. Inter-horizontal boundary is diffused or obscure.
15–60	Light reddish-brown slightly compact clay. Horizontal boundary in the substratum is wavy and diffused or obscure.
60–150	Weathered andesite rock.

The average depth of the surface soil is 15 to 18 centimeters on areas not badly eroded. The subsoil is not distinct, but where it is clear and distinct, the depth is about 60 centimeters from the surface. The coarse skeleton found on the surface soil and upper subsoil is a mixture of rounded and angular fragments of andesite rocks.

This type covers an area of 5,740 hectares. The upper slopes of this area is covered with second-growth forest. The lower slopes are planted to ipil-ipil, upland rice (in kaingins), bananas, root crops, sugar cane, and corn. Lanzones and coconuts are grown in the vicinity of San Pablo.

Macolod clay loam, steep phase (*144*).—This phase is found on the upper slopes of Mts. Makiling and Nagcarlan. It has the same profile characteristics as the clay loam type, except for its steeper slopes, abundant boulders, cobblestones, and pebbles on the surface soil. The surface soil is thin owing to severe soil erosion. The slope is so steep that there is little attempt on the part of the farmers to cultivate the land regularly.

On Mt. Makiling this phase is covered with second-growth forest, ipil-ipil, bananas, sugar cane, corn, root crops, and upland rice (in kaingins). In the neighborhood of Nagcarlan coconut trees and lanzones are grown. This soil phase covers an area of 9,611.8 hectares.

To minimize soil erosion, ipil-ipil should be planted closely; kaingins should be discouraged or prohibited; and the outlay of timber must be well supervised.

Macolod soils, undifferentiated (*145*).—The uppermost portion of Mt. Makiling was left unclassified. It is unsuited to agriculture due to its rough and steep topography. It constitutes the mossy forest type, because mosses grow on forest trees owing to high elevation. Only forest trees and ferns are able to grow on this area. It comprises the Makiling National Park reserved by the Bureau of Forestry, covering an area of 5,579.2 hectares.

Mountain soils, undifferentiated (*45*).—This area represents the rough mountainsides and forested region that are not accessible. For the purpose of the survey, this area is not classified. It is thickly covered with forest of good commercial timber.

MORPHOLOGY AND GENESIS OF SOILS

Generally, soil is the function of five factors, namely, parent materials, relief, climate, vegetation, and time. Its characteristics are essentially determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has been formed since accumulation; (3) the relief of the land which influences the internal and external drainage and susceptibility to erosion; (4) the biological forces (plants and animals) acting upon the soil material; and (5) the length of time the climatic and biologic forces have acted on the soil material.

These factors on soil-forming processes are inter-dependent, each modifying the effectiveness of the other. Their importance, however, depends upon their dominant influences upon the

other. When the climatic and biologic factors have dominant influence over the parent material, relief, and time, the soil formed or developed belongs to the zonal soils, such as red and yellow soils, true Prairie soil, lateritic and laterite soils, black earth or chernozems and chestnut brown soils. However, if the parent material, time, and relief have dominant influence over the climatic and biological factors, the so-called intra-zonal soils are formed. These soils are generally the halomorphic soils, saline and alkali soils, water ground laterite and others. These are generally young or immature soils. If none of these five factors has ascendancy over any other, the soil exhibits no profile development.

Fundamentally, the soils of the Philippines belong to the soil groups known as red and yellow soils, and laterites and lateritic soils of the Tropics. Within these groups are other mature or immature soils with and without true soil profiles. These soils are the products of the dominance of climatic and biologic factors over the relief, parent material and time.

Local climatic and biological influences over parent material, relief and time, particularly in Laguna Province have produced a varied series of soils that can be grouped according to their profile development. Based on the Key to the Soil Series of California, the soils of Laguna are arranged into the following profile groups:

1. Profile group I.
   - (*a*) Bay clay.
   - (*b*) Taal fine sandy loam.
2. Profile group II.
   - (*a*) Marikina silty clay loam.
   - (*b*) Marikina silt loam.
   - (*c*) Quingua fine sandy loam.
3. Profile group III.
   - (*a*) Maligaya clay loam.
4. Profile group IV.
   - (*a*) Guadalupe clay.
   - (*b*) Calumpang clay.
   - (*c*) Calumpang clay loam.
5. Profile group VI.
   - (*a*) Lipa loam.
   - (*b*) Carmona clay loam.
   - (*c*) Tagaytay sandy loam.
6. Profile group VII.
   - (*a*) Macolod clay loam.
   - (*b*) Luisiana clay loam.
   - (*c*) Paete clay loam.
   - (*d*) Antipolo clay.

Profile group I are soils on recent alluvial fans, flood plains or other secondary deposits having undeveloped profiles underlain by unconsolidated material. The Bay clay and Taal fine sandy loam types fall under this group. Both these types have undeveloped profiles.

Profile group II are soils on young alluvial fans, flood plains or other secondary deposits having slightly developed profiles, underlain by unconsolidated material. These profiles have slightly compact subsoil horizons. The soil types under this group are Marikina silty clay loam, Marikina silt loam, and Quingua fine sandy loam. These soils are all alluvial deposits that have developed recently, forming slightly developed profiles.

The soils of profile group III are on older alluvial fans, flood plains or terraces having moderately developed profiles (moderately dense subsoils) underlain by unconsolidated material. These are generally deep soils in that they are not underlain by clay pans but the subsoils are moderately dense. The Maligaya clay loam belongs to this group. This type is located on the upper terraces of the alluvial plains and has a moderately developed profile.

The soils of profile group IV are on older plains or terraces having strongly developed profiles (dense clay subsoils) underlain by unconsolidated materials. These soils have secondary clay pan soils to which the Guadalupe clay, Calumpang clay and Calumpang clay loam belong. These three soil types are all developed from the weathered volcanic tuff material located on the upper terraces of the plain. The depth of the soil depends upon the extent of the predominating forces of formation that have acted on the soil material.

The soils of profile group VI are on older terraces and upland areas having dense clay subsoil resting on moderately consolidated material. Many of the soils in upland or high terraces belong to this group. In Laguna Province, the Lipa loam, Carmona clay loam, and Tagaytay sandy loam are classified under this profile grouping. These soils should have been classified under profile group IV, but because of their location on older terraces and upland areas with moderately consolidated material, they are classified under profile group VI.

The soils of profile group VII are on the upland areas developed on consolidated or hard igneous bed rocks.

These soils have formed from the weathering of the underlying igneous rocks and occupy sections of rolling to steep topography. The soils under this group are Macolod clay loam,

Luisiana clay loam, Paete clay loam, and Antipolo clay. These soils are all located in the rolling and steep uplands where the underlying bedrock consists of volcanic basalt. In the case of Antipolo and Luisiana clay, the development of the surface soil, subsoil and substratum have gone so far that the bedrock is seldom observed in the profile.

PRODUCTIVITY RATINGS OF LAGUNA SOILS *

The productivity rating of soils is one of the latest features to be included in soil survey reports to supplement the description of soil types. These ratings are made during and after the field operation by assigning to each of the types of soil concerned an index number which represents its crop productivity compared to the standard productivity of a specific crop (100). This standard productivity is the approximate average yield obtained from a given crop without the use of amendments or fertilizers on the more extensive and better soils of the area where such crop is grown principally. A rating of 50, for example, indicates that the soil type is one-half as productive for the specific crop as soils with the standard index of 100. Usually productive soils, or soils treated with amendments or fertilizers, yield larger crops than the standard, in which case they are rated above 100.

The primary aim in making these ratings is to bring about more specifically the soil type and crop relation, or give the comparative productiveness of the individual types of soil. These ratings are obtained either by inductive or deductive method. In the inductive method, the profile characteristics are considered in relation to their effect upon the production of the crops in mind. Such factors as imperfect drainage, content of organic matter, and texture of the surface soils are considered in terms of their effects on the productivity in question.

An inductive method of rating soils was devised by Storie of the University of California. This method employs three general factors which are more likely to influence the productivity of the most profitable crops of the area. The first factor called "A" consists of the soil profile and its general characteristics; the second called "B" consists of the texture of the surface soil; and the third factor called "C" consists of miscellaneous conditions, such as chemical properties, drainage, etc. These factors are expressed in percentage and to get the final ratings they are multiplied together. The disadvantage of this

* The productivity rating of each crop is based on the average annual production thereof as given by the farmers in the field during the course of the surevy.

system is that it takes only one of these three factors to bring down the rating, even if the other two are rated 100 per cent each.

In the deductive process, ratings are assigned to the yields that are considered to be representative of the specific crops grown on a particular soil. The following are the average yields per hectare that have been established as standards of 100:*

1. Coconut—Nuts per hectare	3,750
2. Sugar cane—Piculs sugar per hectare	80
3. Lowland rice—Cavans per hectare	60
4. Upland rice—Cavans per hectare	30
5. Corn—Cavans per hectare	17
6. Bananas—Bunches per hectare	900
7. Sweet potatoes—Tons per hectare	8
8. Pineapple—Fruits per hectare	7,500
9. Lanzones—Baskets per hectare	130

The above crops are arranged according to their importance in the province of Laguna. The productivity rating of the different soil types for these crops are shown in Table 13.

TABLE 13.—*Productivity ratings of the soils in Laguna Province*

Type number	Soil types	Coconut	Sugar cane	Lowland	Upland	Corn	Bananas	Sweet potatoes	Pineapple	Lanzones
4	Quingua fine sandy loam	.....	90	65	90	130	65	130	70	.....
18	Guadalupe clay	.....	60	90	.....	85	.....	.....	.....	.....
19	Guadalupe clay adobe	.....	.....	.....	20	30	.....	.....	.....	.....
20	Marikina silt loam	90	75	.....	90	100	55	110	55	.....
139	Marikina silty clay loam	.....	55	75	.....	100	60	90	.....	.....
26	Antipolo clay	90	.....	.....	80	40	60	40	50	80
27	Antipolo clay loam	.....	.....	45	40	45	.....	.....	.....	.....
36	Tagaytay sandy loam	80	60	.....	40	45	50	55	40	.....
39	Carmona sandy clay loam	.....	60	70	.....	80	60	90	.....	.....
40	Carmona clay loam	.....	35	.....	30	50	40	40	45	.....
52	Calumpang clay loam	100	75	.....	40	80	70	70	.....	.....
147	Calumpang clay	.....	60	90	.....	80	60	.....	.....	.....
57	Taal fine sandy loam	80	60	.....	40	45	55	55	40	.....
58	Lipa loam	110	100	65	90	120	80	100	110	100
148	Lipa loam, steep phase	50	.....	.....	40	40	50	40	40	.....
117	Maligaya clay loam	.....	60	85	.....	100	65	60	60	.....
140	Luisiana clay loam	120	35	50	40	60	60	65	80	70
141	Paete clay loam	90	.....	.....	40	.....	.....	.....	.....	80
142	Macolod clay loam	85	60	.....	70	70	85	75	65	80
143	Macolod clay loam, steep phase	70	40	.....	50	70	70	55	45	55
146	Bay clay	.....	.....	85	.....	.....	.....	.....	.....	.....

There are a number of factors that determine the productivity of the land, namely, climate, soil, slope, drainage, and management. These factors do not operate independently of one another. However, in certain instances one or two of

* As obtained in the field while the survey work was in progress.

these may dominate the others in the production of certain crops. Fluctuations in yield of crops from year to year are often due to fluctuations in climate. In rice lands, especially those for upland rice, natural drainage is important for good production. In lowland rice fields, however, the more retentive the soil is for water, the better for the rice crop.

Under Laguna conditions the Lipa loam is considered productive and well adapted to crop diversification. Lowland rice is well adapted to the heavy-textured soils, such as Calumpang clay, Bay clay, Guadalupe clay, and Maligaya clay. Corn and sweet potatoes grow best in Quingua fine sandy loam, while bananas and other fruit trees do well in Macolod clay loam.

CHEMICAL CHARACTERISTICS OF THE SOILS OF LAGUNA PROVINCE

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The soil survey of Philippine soils as conducted by the Division of Soil Survey and Conservation involves, firstly, genetic, morphologic, and cartographic studies in the field, and secondly, physical, chemical, and biological investigations in the laboratory. The laboratory investigations, especially the chemical, are an aid to the formulation of farm practices and cropping system, and also in the study of the origin and formation of the soil type. Thus, complete chemical studies reveal (1) what nutrient elements needed by the plant for its growth and reproduction are deficient or are in excess; (2) what toxic substances are present or what elements exist in toxic concentrations; (3) the average reaction of the soil type, which is a distinct aid in determining the natural crop adaptability of that soil type; and (4) what may be the expected crop response to fertilization of a particular soil identified.

Plants need in rather large quantities the essential elements carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, while iron, boron, copper, manganese and zinc are needed in much less quantities for their metabolism. The latter group of elements are classified as trace or rarer essential elements with regards to plant nutrition because they are needed in such minute quantities as in the magnitude of one-fourth part per million in the soil solution. With the exception of carbon, hydrogen, and oxygen, which are derived from the air and water, all these nutrient elements are derived by plants from the soil. Adverse effects on quality and quantity of crop yields are caused by a deficiency or absence of any of these elements in the soil.

Elements usually present in critical or inadequate amounts in the soil are nitrogen, phosphorus, and potassium which are commonly supplemented by the addition of manures and commercial fertilizers. Minor or secondary nutrient elements which may occasionally be present in insufficient amounts are calcium and magnesium and the correction for this condition is made by the addition of dolomitic limestone.

METHODS OF CHEMICAL ANALYSIS

The methods of determining the replaceable or readily available constituents were preferred to those of determining the total constituents for two considerations: (1) Except for total nitrogen and total phosphorus, facilities for total analysis are not yet available in our laboratory; (2) the results obtained with the rapid or availability tests correlate with plant growth or the response of plants to fertilizer treatments better than those of the total analysis.

Rapid chemical tests for the readily available soil constituents are being standardized for Philippine conditions, basing on actual results of fertilizer and liming experiments conducted in the greenhouse and in the field. While studies along this line are still underway in the Division of Soil Survey and Conservation, selected availability tests successfully used abroad had been followed in the study of the soils of Laguna Province.

Soil reaction or the hydrogen-ion concentration of the soil was determined by the potentiometric method, using the glass electrode. Total nitrogen content of the soil was determined according to the "Methods of Analysis" of the Association of Official Agricultural Chemists of the United States. (7) * The available constituents nitrates, ammonia, and replaceable calcium were determined by the methods of Spurway. (26) For the readily available phosphorus determination, the method of Truog (29) as modified by Marfori (17) was followed. Available potassium was determined according to the method of Peech and English (21) and the interpretation of the result made according to the findings of Bray. (8)

INTERPRETATION OF CHEMICAL TESTS

Soil reaction or pH value. † Soil reaction is a very important limiting factor for plant growth. It affects the behaviour and availability of plant nutrients in the soil. In very strongly acid soils, or soils of very low pH value, toxic concentrations of aluminum and manganese may develop and retard plant growth. In very alkaline soils, or those with very high pH

* The numbers in parenthesis refer to Literature cited, p. 83.

† Soil reaction means the degree of acidity or alkalinity of the soil expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, lower values indicate acidity, and higher values indicate alkalinity.

values, iron, manganese and phosphorus become unavailable to plants, and thus cause their malnutrition or abnormal growth.

Different plants have been found to have different optimum soil reaction requirements or preferences and different tolerance limits. Table 14 shows the pH requirements of some economic plants. It can be seen from these data that some plants, like rice, pineapple, and tobacco, prefer medium acid soils (pH 5.5 to 6.1), while other species like sugar cane prefer more alkaline condition (pH 6.2 to 7.8). However, some plants like corn, soybean, and tomato can tolerate rather wide pH ranges (4.8 to 8.5), although their optimum soil reactions are of narrower ranges (pH 5.5 to 7.0).

TABLE 14.—*The pH requirements of some economic plants.*[a]

[X, most favorable reaction; O, unfavorable reaction; y, reaction at which plants may grow fairly well or normally.]

Plants	Soil reaction					
	Strongly acid pH 4.8–5.4	Medium acid pH 5.5–6.1	Slightly acid pH 6.2–6.9	Neutral reaction pH 7.0	Slightly alkaline pH 7.1–7.8	Medium alkaline pH 7.9–8.5
Bean, lima (*Phaseolus lunatus* Linn.)	.....	y	x	y	y	.....
Corn or maize (*Zea mays* Linn.)	y	y	x	x	y	y
Lettuce (*Lactuca sativa* Linn.)	0	y	x	y	0	0
Onion (*Allium cepa* Linn.)	0	y	x	y	y	y
Orange, sweet (*Citrus sinensis* Osbeck)[b]	.....	y	x	x	x	y
Peanut (*Arachis hypogaea* Linn.)	y	y	x	x	y	.....
Pineapple [*Ananas comosus* (Linn.) Merr.]	y	x	y	0	0	0
Rice (*Oryza sativa* Linn.)	y	x	y	0	0	0
Soybean [*Glycine max* (Linn.) Merr.]	y	x	x	x	y	y
Sugar cane (*Saccharum officinarum* Linn.)	0	y	x	x	x	y
Sweet potato [*Ipomoea batatas* (Poir.)	y	x	x	y	0	0
Tobacco (*Nicotiana tabacum* Linn.)	y	x	y	0	0	0
Tomato (*Lycopersicum esculentum* Mill.)	y	y	x	x	y	

[a] Data taken from Weir, Wilbert Walter, Soil Science, its principles and practice, J. B. Lippincott Co., Chicago and Philadelphia, 1st. ed. (1936) 1–615.

[b] From Spurway, C. H. Soil reaction (pH) preferences of plants. Mich. Agr. Exp. Sta. Sp. Bull. 306 (1941). Optimum range given was pH 6.0–7.5.

Table 15 shows the average chemical analysis of the surface soil of the principal soil types in Laguna Province.

Rice, pineapple, and tobacco which can tolerate a pH range of 4.8 to 6.9 can be grown on all the major soil types of the province as far as soil reaction is concerned. Sugar cane, however, will require the application of lime to correct the acidity of some of the soil types, especially of Carmona sandy clay loam and Taal fine sandy loam.

Nitrogen.—Being a constituent of protein, nitrogen is needed by every living plant and animal cell. The most apparent effect of nitrogen on plant growth is in the development of the

vegetative portion of the plant. An ample supply of available nitrogen in the soil may stimulate growth and hasten maturity, but the presence of excessive amounts tend to produce excessive vegetative growth and delay maturity. Soils well supplied with nitrogen produce dark-green leaves in plants, while those deficient in nitrogen cause chlorosis or yellowing of leaves and in severe cases, slow stunted growth.

TABLE 15.—*Average chemical analysis of the surface soil of the major soil types in Laguna Province*

Type number	Soil type	pH value	Available constituents in parts per million (p.p.m.). Total nitrogen (N).	Ammonia (NH_3).	Nitrates (NO_3).	Phosphorus (P).	Potassium (K).	Calcium (Ca).
			Per cent					
4	Quingua fine sandy loam	6.52	0.09	2	10	53.5	293	100
18	Guadalupe clay	6.34	0.15	2	5	13.0	115	100
20	Marikina silt loam	6.67	0.30	2	5	45.0	542	100
139	Marikina silty clay loam	5.95	0.32	2	2	13.5	150	40
26	Antipolo clay	6.51	0.19	2	10	6.0	207	100
27	Antipolo clay loam	5.25	0.23	10	5	4.0	700	20
36	Tagaytay sandy loam	5.80	0.14	2	2	5.0	264	60
39	Carmona sandy clay loam	4.88	0.23	10	2	5.0	145	40
32	Calumpang clay loam	6.64	0.18	2	20	23.5	430	100
147	Calumpang clay	6.05	0.19	2	20	28.5	208	40
57	Taal fine sandy loam	5.44	0.16	5	2	5.0	110	20
62	Lipa loam	5.94	0.13	2	25	32.0	240	40
117	Maligaya clay loam	5.27	0.25	2	5	17.5	241	60
140	Luisiana clay loam	6.59	0.21	2	5	27.5	640	100
141	Paete clay loam	6.12	0.12	2	2	12.0	260	100
143	Macolod clay loam	6.47	0.23	2	2	25.5	293	20
146	Bay clay	6.04	0.26	2	2	17.5	257	20

A large supply of available nitrogen has been known to decrease crop yield as well as the resistance of plants to diseases. Excessive nitrogen causes lodging of rice, wheat, and other small grains, lowers the purity of sugar cane juice, and decreases the tensile strength of bast fibers in fiber plants. However, for certain crops, like leafy vegetables and forage grasses where succulence may be desirable, an abundance of nitrogen in the soil is doubly an asset.

In soils, nitrogen is found chiefly in the organic matter, either in the decaying organic residues or in the complex substances synthesized by soil microorganisms. When a nitrogenous organic matter decomposes, its nitrogen is converted first into ammonia, then into nitrites, and finally into nitrates through the action of specific soil microorganisms in a process called nitrification. To maintain the production of nitrates through such a process the soil must be moist, warm, and sufficiently aerated, besides having the proper microbes and a supply of nitrogenous organic matter.

Most plants obtain their nitrogen from the soil as nitrate, while rice and other members of the grass family can assimilate nitrogen in the ammoniacal form. In the latter form, nitrogen can be fixed in the soil and therefore not easily lost, while a nitrate, being very soluble, can easily be lost by the soil through leaching. Where a deficiency of nitrogen in the soil is to be corrected by the application of nitrogenous fertilizers, the choice of fertilizers will depend on the cropping system. Where immediate availability is desired as in the growing of vegetables or short-season crops, nitrates are ideal carriers of nitrogen. In combination with calcium or with sodium, nitrates tend to reduce soil acidity, unlike the ammoniacals which generally increase soil acidity. However, for most crops ammonia nitrogen is preferable to nitrate nitrogen as far as efficiency and cheaper cost are concerned.

Compared with the agricultural soils of other provinces in the Philippines so far surveyed, which gave approximately 0.10 per cent of total nitrogen on the average, the principal soils of Laguna Province are generally quite high in their total nitrogen contents, ranging from 0.09 to 0.32 per cent. With the exception of the Quingua fine sandy loam which has 0.09 per cent total nitrogen, all the other soil types analyzed gave higher values than 0.10 per cent.

According to the interpretations of Spurway, the low content of ammonia (2 to 5 p.p.m.) is normal for many soils, because the formation of ammonia is the first step in the production of soil nitrates. It may be that when the ammonia is converted into nitrites and nitrates, it is fixed in the soil complex, or it is used up by plants as fast as formed. Comparatively high tests for ammonia (10 to 25 p.p.m.) may mean soils with very high content of decaying organic matter, freshly manured soils, or soils recently fertilized with ammonia compounds. On the Laguna soils tested, Antipolo clay loam and Carmona sandy clay loam gave high values for ammonia (10 p.p.m.). Both these soil types have rather high total nitrogen contents (0.23 per cent).

Spurway considers 2 to 5 p.p.m. of nitrates as low, 10 to 25 p.p.m. as medium or normal supply, and 100 p.p.m. or more as very high or excessive with harmful effects on plant growth to be expected. Unlike the tests for available phosphorus and potassium, these tests for the various forms of nitrogen are not specific, taken individually, in diagnosing whether or not a soil has a sufficient supply of available nitrogen throughout

the growing season of a crop. The results of the three nitrogen tests have to be interpreted together to be of some diagnostic value. Low nitrate test with chlorotic and stunted plants indicates nitrate deficiency. Low nitrate test may also mean that the nitrate is taken in by the crop as fast as produced, or that it is lost from the soil by leaching. High ammonia with low nitrate test may indicate that some unfavorable soil conditions are interfering with nitrate formation.

The data in Table 15 show that there is probably no major soil type in Laguna Province that is really deficient in nitrogen. This may be substantiated by the fact that reports on the lodging of rice, particularly in the lowland rice fields of Sta. Rosa, Cabuyao, Calamba, and Calauan are not uncommon. A perusal of the figures in Table 13 which gives the productivity ratings of the soils in the province, and those in Table 15 shows that those soil types which are much more productive than the others (productivity ratings of 100 or more in one crop, or 90 in at least two crops) have rather high total nitrogen, ammonia, or nitrate tests. These soil types are Quingua fine sandy loam, Marikina silt loam, Marikina silty clay loam, Calumpang clay loam, Lipa loam, Maligaya clay loam, and Luisiana clay loam. Lipa loam, which according to the productivity ratings (100 or more in six out of the nine crops) is probably the most productive soil type in the province, gave the highest nitrate content (25 p.p.m.).

Phosphorus.—Like nitrogen, phosphorus is a constituent of every living cell. In the absence of phosphorus, cell division in plants is retarded and growth is stunted. Phosphorus is needed in the formation of seed and has a marked influence on hastening the maturity of crops, especially grain crops. It also stimulates root development, particularly of the root crops like sweet potato. In plants, phosphorus is needed in the production of nucleo-proteids, of fats and albumin, and in the conversion of starch into sugar.

On phosphorus-deficient soils, the stunted plants usually have dark green color and some plants, like corn, develop reddish or purplish coloration on the leaves and stems. Insufficiency of phosphorus delays seed formation and maturity of the crop in general. But probably the most characteristic symptom of phosphorus deficiency is stunted growth.

Truog, using his method (29), tentatively set the minimum limit of readily available phosphorus for general farming under Wisconsin conditions at 37.5 p.p.m. for the heavier, better soils, and at 25 p.p.m. for very sandy soils. He also suggests that

for certain sections in the southern part of the United States, where the climate makes possible a longer growing period than in the northern part, 10 to 15 p.p.m. of readily available phosphorus might suffice for a good crop of corn. Marfori (17) found that Philippine rice soils containing as much as 37.3 p.p.m. of available phosphorus as determined by the Truog method responded very little to phosphatic fertilization. While more extensive studies along this line had been disrupted by the last war, and the present investigations have not yet yielded enough results, reliable estimates may be made. For some Philippine soil types, at least, 30 to 40 p.p.m. of available phosphorus may not be far from the minimum limit that will suffice for a good crop of rice.

Data from Tables 13 and 15 will show that the three most productive major soil types in Laguna as found in the field survey, namely, Lipa loam, Quingua fine sandy loam, and Marikina silt loam, gave available phosphorus tests ranging from 32.0 to 53.3 p.p.m. Quingua fine sandy loam which gave the highest phosphorus test has the highest productivity rating for the root crop (sweet potato, 150), and the grain crop (corn, 100, and upland palay, 90). Marikina silt loam which gave the available phosphorous test of 45.0 p.p.m., has the second highest productivity rating for the root crop (sweet potato, 110), and the highest rating for upland rice (90) and third highest rating for corn (100). Lipa loam which had an average available phosphorous content of 32 p.p.m. is excellent for most crops (100 or more in six of the nine leading crops). It may be mentioned here also that in spite of its fairly high total nitrogen and ammonia contents and its very high content of available potassium, Antipolo clay loam does not rate higher than 45 in productivity for either rice or corn which are its only principal crops. The very low productivity of this soil type may be due to its extremely low available phosphorous content (4.0 p.p.m.).

Potassium.—Plants usually require and contain more potassium than any of the other essential nutrient elements coming from the soil. About 40 per cent of the ash of most plants consists of potassium as K_2O or potash. Unlike phosphorus, potassium is not highly concentrated in any part of the plant although it tends to accumulate in the leaves and stems rather than in the grain. One of the most important functions attributed to potassium is its effect on the plant synthesis of carbohydrates and proteins. Potassium is needed in the production of starch, sugar, and other carbohydrates and in the translocation of

starch and other materials within the plant. It is also needed in the development of chlorophyll and in the synthesis of oils and albuminoids. Potassium improves the general vigor of the plant and makes it more disease-resistant. Potassium increases plumpness in grains, and makes the stalk and straw of plants more rigid, thus minimizing lodging.(10)

A deficiency of potassium in the soil causes marked disturbances in plants. The leaves become yellowish or dull-colored at the tips and margins and finally brown, spreading upward and inward toward the centers. The deficiency may cause also the formation of small, shrunken, or misshaped flowers, pods, fruits, tubers, and roots.

Potassium is found in both organic and mineral matter of the soil but occurs chiefly in the mineral portion and becomes available to plants through solution in soil water, action of weathering, and base exchange. All soils except peats and mucks, contain relatively large amounts of total potassium but the amount available to plants is generally small, especially in sandy soils.

The great bulk of the soil potassium usually exists in the hardly available or nonreplaceable form, principally in primary minerals such as the feldspars and micas which are prominent constituents of igneous rocks. A small portion of the total potassium, usually not more than one per cent, is present in available or replaceable form, that is, in the clay minerals (principally kaolinite, montmorillonite, beidellite, etc.). The portion of total potassium that is water-soluble is still much smaller than that in replaceable form, and it is a blessing to agriculture, for it is the water-soluble potassium that is easily lost by the soil in leaching or in drainage.

In some soils where the base exchange capacity is rather large and the total exchangeable or replaceable bases present are much smaller in amount, part or all of the potassium added as fertilizers is fixed in the clay mineral exchange complex and may be considered stored for the future use of plants.

The data on available potassium of the major soil types in Laguna Province had been obtained with the method of Peech and English.(21) Because no figures for the minimum potassium requirements of plants are given with this method, and fertilizer and liming studies for the standardization of rapid chemical tests suitable for Philippine conditions are still underway, the data of Bray (8) for available potassium which were obtained with a similar procedure are referred to for evaluating roughly the potash fertilizer needs of the Laguna soils.

According to Bray, for most Illinois or Corn Belt soils, corn or clovers will not respond to potassium fertilization, when the available soil potassium is 150 p.p.m. (300 pounds per acre) or more. The minimum requirement for soybeans is about 100 p.p.m., while that for wheat or oat is about 65 p.p.m. of replaceable potassium. In a more recent report (Linsley (15), Bray recommends 100 p.p.m. (200 pounds per acre) of available potassium as the minimum requirement for the principal Illinois crops to be grown in a 4-year rotation.

Since the estimated average amounts of potash removed from the soil by normal crops of coconut and rice—the two most important crops of Laguna Province—are about the same (98 kilograms per hectare) and both amounts are less than that (132 kilograms per hectare) removed by a normal corn crop (1) it may be assumed that the average minimum potassium requirements of the principal crops of the province is around 100 p.p.m. With this assumption, all the major soil types of Laguna Province seem to be sufficient in available potassium, which ranges from 110 to 700 p.p.m. Lipa loam, Quingua fine sandy loam, and Marikina silt loam, which have been rated as the three most productive soil types in the province, have fairly high contents of available potassium, ranging from 240 to 542 p.p.m.

Calcium.—For the growth of plants, calcium performs many important functions in the soil. It is a nutrient element found in relatively large quantities even in unlimed soils. Added as a liming material, calcium neutralizes the acidity of acid soils and corrects the toxic conditions sometimes caused by soil acidity. A rather large amount of available calcium is needed by beneficial microorganisms in the soil, and by legumes and sugar cane. The grains and grasses, however, generally use smaller amounts. The calcium content of the soil affects its physical structure. Since calcium causes flocculation of soil colloids, soils high in calcium content are generally friable and easy to cultivate, while clayey soils deficient in calcium are generally easily puddled and sticky.

According to Spurway, whose method for determining available soil calcium had been followed in testing the Laguna soils, low calcium test, below 40 p.p.m., indicates a low available supply and, if the soil is acid, also emphasizes the need for liming to grow "high-lime" crops. He considers 100 to 150 p.p.m. of available calcium good for most plants, while higher amounts may be excessive especially for plants with low pH preferences.

The figures in Table 15 show that of the 17 major soil types identified and studied in Laguna Province, four soil types may be considered very low (20 p.p.m.), four as low as (40 p.p.m.) and the rest of the soil types as sufficient in available calcium (60 to 100 p.p.m.), according to Spurway's interpretation. None of the soil types with very low available calcium (20 p.p.m.) rated 90 in productivity in any one crop. While in the low-available calcium group (40 p.p.m.), Marikina silty clay loam rated 100 in corn and 90 in sweet potatoes, Carmona sandy clay loam rated 90 in sweet potatoes, Calumpang clay rated 90 in lowland palay, and Lipa loam rated as the most productive soil type of the province for most crops. From these data it may be inferred that, as determined by the Spurway method, 40 p.p.m. of available calcium may be considered *not low*, if not totally sufficient for most crops under Laguna conditions. Liming experiments, the results of which will be used in calibrating tests for available calcium under Philippine conditions, are still underway in the Division of Soil Survey and Conservation.

SUMMARY

Laguna Province is in the southeastern part of Luzon, situated on a narrow plain which lies to the east, south, and southwest of Laguna de Bay. The land cover of the province is 187,000 hectares. Generally, the province is mountainous and hilly with a comparatively narrow piedmont plain which extends from the western to the eastern end of Laguna de Bay. These mountains and rolling uplands are dissected by several rivers and numerous creeks which originate from the upland and empty into the Bay.

Water supply is plentiful especially in the upland towns of the province bordering the three prominent mountains, namely, Makiling, Cristobal, and Banahao.

The narrow piedmont plain between the Laguna de Bay and the upland is lowland rice field. The slightly undulating upland is devoted to sugar cane, upland rice, fruit trees, coconuts, bananas, and other cash crops of minor importance. The mountains and uplands have an evergreen vegetation consisting of coconuts, commercial and noncommercial forests.

Civil government was established in Laguna on July 1, 1902. There are 28 municipalities and one chartered city, San Pablo. Sta. Cruz is the capital of the province and is 98 kilometers from Manila. The total population of the province is 279,505 (1938).

First- and second-class roads connect all the towns of the province, so that transportation facilities are adequate and fast.

The commercial centers of the province are the towns of Biñan, Calamba, San Pablo, Sta. Cruz, and Pagsanjan. Adequate postal and telegraph service is also available in the province.

The public health and sanitary condition of the province is adequate. Regional public physicians and Sanitary Inspectors are assigned in the most important towns.

All the towns and important barrios have primary and elementary public schools. A public high school maintained by the Bureau of Education is located in Sta. Cruz. Private secondary schools are found in San Pablo, Pakil, Pagsanjan, Calamba, Cabuyao, Biñan, and Sta. Rosa. The two highest institutions of learning of their kind in the Islands, the College of Agriculture and the School of Forestry, are located at the foot of Mt. Makiling in Los Baños.

The people are Roman Catholics with the exception of a few inhabitants of the inland towns who are affiliated with the Protestant, Aglipayan, and Church of Christ religions.

Agriculture is the basic industry of the people. Fishing and duck raising are the other industries and these are confined to the towns and barrios bordering Laguna de Bay. Wooden shoes are made in Paete and Calamba, pottery in San Pedro, and slippers in Biñan. The industries of the inland towns are varied. Hats and bayong from pandan leaves are made in Cavinti, Luisiana, Nagcarlan and Lilio, sabutan hats in Mabitac, and rattan chairs in Pañgil.

Laguna Province falls under the first type of climate—two pronounced seasons, dry from December to May, and wet from June to December. Rainfall is heavy during the months of June, July, August, and September. The presence of numerous hills and prominent mountains protect the province from violent typhoons.

Laguna is an agricultural province. The ten leading crops are coconut, palay, sugar cane, corn, pineapple, tomatoes, gabi, camotes, bananas, and lanzones. The province has a farm area of 100,100.47 hectares, and the area under cultivation is 84,520.17 hectares, or 84.4 per cent. It has a total of 25,720 farms, each averaging 3.89 hectares in size. There are three haciendas in the province, namely, Hacienda Calauan, Canlubang Sugar Estate, and Central El Real. These haciendas practice modern methods of farming, while the rest of the farmers stick to the old primitive method of agricultural practices.

The soils of Laguna Province are grouped into three general land types based on relief, namely, (1) Soils of the fresh water marshes, (2) soils of the plains, and (3) soils of the rolling areas, hills and mountains. The hydrosols or the fresh-water marsh has an area of 4,899.4 hectares, or 2.62 per cent of the total area of the province. It has no agricultural value except for the growth of hydrophytic plants where fish ponds are built.

The soils of the plains with an area of 27,514.7 hectares, or 14.71 per cent, comprise eight soil series, twelve soil types and one soil phase, the flat and heavy-textured soils, like the Calumpang clay and clay loam, Guadalupe clay and clay adobe, Maligaya clay loam, Carmona clay loam, Carmona sandy clay loam, and Marikina silty clay loam are utilized for lowland-rice culture. The soil types suited for rice are the following: (1) Maligaya clay loam with an average yield of 50 to 60 cavans per hectare, (2) Calumpang clay and clay loam, 50 to 60 cavans, and (3) Guadalupe clay, 50 to 60 cavans. The Marikina silt loam and Quingua fine sandy loam are utilized for sugar cane, upland rice, corn, vegetables, pineapple, and other crops. The largest soil type mapped and delineated in this group of soils is the Calumpang clay with 6,694.6 hectares, or 3.58 per cent, followed by the Guadalupe clay with an area of 4,768.5 hectares, or 2.55 per cent, and the Maligaya clay loam with an area of 4,656.3 hectares, or 2.49 per cent.

The soils of the rolling areas, hills and mountains have a total land cover of 154,595.9 hectares, or 82.67 per cent. Out of this hectarage, 48,443.5 hectares, or 25.91 per cent, is represented by the undifferentiated and mountain soils of the province. This is classified also as nonagricultural land. The rest of the area which is composed of six soil series and eight soil types represents the agricultural land of the rolling and hilly areas. The largest soil type mapped and delineated in this group was the Lipa loam comprising of 46,179.5 hectares, or 24.69 per cent. Sugar cane is the principal crop grown in this type of soil, with upland rice, corn, pineapple and fruit trees as secondary crops. Three new soil series are mapped and delineated in this area, namely, Macolod series, Paete series, and the Luisiana series. Among the three soil series newly established, Luisiana has the greatest hectarage with a total area of 27,152.4 hectares, or 14.52 per cent. This soil series is devoted to coconuts and other fruit trees. Next to this is the Macolod

series with an area of 15,351.8 hectares, or 8.21 per cent. This section is devoted to bananas, fruit trees, upland rice, and corn. Paete series has the least area with only 4,731.1 hectares, or 2.53 per cent. The area is devoted to coconuts and fruit trees such as lanzones, jackfruit, santol, citrus, and others. This is the very soil series that produces the best quality of lanzones.

The soils of Laguna are generally fertile, but due to topography and the present soil management commonly practiced by the farmers, time will come when these soils will lose their fertility. The Government should remedy the soil erosion that is taking place every time these soils are touched, so as to preserve their natural fertility.

In so far as soil reaction is concerned, rice, pineapple, tobacco, and other acid-tolerant plants can be grown on all the major soil types of Laguna Province, while sugar cane and other acid-sensitive plants will require the application of lime to correct the acidity on some of the soil types especially on Carmona sandy clay loam, and Taal fine sandy loam.

Compared with the agricultural soils of other provinces in the Philippines so far surveyed, which gave approximately 0.10 per cent of total nitrogen on the average, the principal soils of Laguna Province are generally quite high in their total nitrogen contents, ranging from 0.09 to 0.32 per cent. Considering the data on total nitrogen, ammonia and nitrates together, there is probably no major soil type in Laguna Province that is quite deficient in nitrogen.

Using the Truog method for determining the readily available phosphorus in soils, only three soil types, the three rated to be most productive in the province, namely, Lipa loam, Quingua fine sandy loam, and Marikina silt loam, were found to contain what may be considered sufficient available phosphorus for Philippine rice soils. The rest of the soil types were found rather low in available phosphorus and therefore may be expected to respond to phosphatic fertilization especially in the case of rice.

It seems that all the major soil types of Laguna Province are sufficient in available potassium. In available calcium, however, four soil types were found to be quite low and these may be expected to respond to liming, especially for such crops as sugar cane and legumes. The rest of the soil types were either moderately supplied or amply provided with available calcium for most crops.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN LAGUNA PROVINCE

Common name.	Scientific name.	Family name.
Abaca	*Musa textiles* Nee	Musaceae.
Achuete	*Bixa orellana* Linn.	Bixaceae.
Agiñgai	*Rottboellia exaltata* Linn.	Gramineae.
Alibangbang	*Bauhinia malabrica* Roxb.	Leguminosae.
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae.
Anonas	*Anona reticulata* Linn.	Anonaceae.
Api-api	*Avicennia officinales* Blanco	Verbenaceae.
Arrowroot	*Maranta arundinacea* Linn.	Marantaceae.
Atis	*Anona squamosa* Linn.	Anonaceae
Avocado	*Persea americana* Mill.	Laureaceae.
Bamboo	*Bambusa spinosa* Roxb.	Gramineae.
Banana	*Musa sapientum* Linn.	Musaceae.
Batao	*Dolichos lablab* Linn.	Leguminosae.
Bermuda grass	*Cynodon dactylon* Linn.	Gramineae
Binayoyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae.
Breadfruit	*Artocarpus communis* Forst.	Moraceae.
Black pepper	*Piper nigrum* Linn.	Piperaceae.
Buri	*Corypha elata* Roxb.	Palmae.
Cabbage	*Brassica oleracea* Linn.	Cruciferae.
Cacao	*Theobroma cacao* Linn.	Sterculiaceae.
Cadios	*Cajanus cajan* (Linn.) Mill sp.	Leguminosae.
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae.
Castor oil bean	*Ricinus communis* Linn.	Euphorbiaceae.
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceae.
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae.
Chico	*Achras zapota* Linn.	Sapotaceae.
Coconut	*Cocos nucifera* Linn.	Palmae.
Coffee	*Coffea arabica* Linn.	Rubiaceae.
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae.
Corn	*Zea mays* Linn.	Gramineae.
Cotton	*Gossypium hirsutum* Linn.	Malvaceae.
Cowpea (paa-yap)	*Vigna sinensis* (Linn.) Savi.	Leguminosae.
Dayap	*Citrus aurantifolia* (Christm) Swingle	Rutaceae.
Duhat	*Eugenia cumini* (Linn.) Druce	Mytaceae.
Eggplant	*Solanum melongena* Linn.	Solanaceae.
Gabi	*Colocasia esculenta* (Linn.) Schott & Endle.	Arcaceae.
Garlic	*Allium sativum* Linn.	Liliaceae.
Guava	*Psidium guajava* Linn.	Myrtaceae.
Guayabano	*Anona muricata* Linn.	Anonaceae.
Indigo	*Indigofera suffruticosa* Mill.	Leguminosae.
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae.
Irish potatoes	*Solanum tuberosum* Linn.	Solanaceae.
Kamachili	*Pithecolobium dulce* (Roxb) Benth.	Leguminosae.
Katmon	*Dillenia philippinensis* Rolfe	Dilliniaceae.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN LAGUNA PROVINCE—Continued

Common name.	Scientific name.	Family name.
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae.
Lanzones	*Lansium domesticum* Correa	Meliaceae.
Lemon	*Citrus limonia* Osbeck	Rutaceae.
Lumbang	*Aleurites moluccana* (Linn.) Wild.	Euphorbiacceae.
Madre cacao	*Gliricidia sepium* (Jacq) Steud	Leguminosae.
Macopa	*Eugenia malaccenis* Linn.	Myrtaceae.
Mandarin	*Citrus nobiles* Lour.	Rutaceae.
Mango	*Mangifera indica* Linn.	Anacardiaceae.
Manzanitas	*Zizyphus jujuba* (Linn.) Lam.	Rhamnaceae.
Mungo	*Phaseolus aureus* Roxb.	Leguminosae.
Mustard	*Brassica integrifolia* (West) Schulz.	Cruciferae.
Nangka	*Artocarpus heterophyllus* Lam.	Moraceae.
Onion	*Allium cepa* Linn.	Liliaceae.
Orange	*Citrus aurentium* Linn.	Rutaceae.
Pandan	*Pandanus tectorius* Sol.	Pandanaceae.
Papaya	*Carica papaya* Linn.	Caricaceae.
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae.
Patani	*Phaseolus lunatus* Linn.	Leguminosae.
Peanut	*Arachis hypogaea* Linn.	Leguminosae.
Pepper	*Capsicum annum* Linn.	Solanaceae.
Pechay	*Brassica chinensis* Linn.	Cruciferae.
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae.
Pili nut	*Canarium luzonicum* (Blume) A. Gray	Burseraceae.
Pummelo	*Citrus maxima* (Burm) Merr.	Rutaceae.
Radish	*Raphanus sativus* Linn.	Cruciferae.
Rice or palay	*Oryza sativa* Linn.	Gramineae.
Santol	*Sandoricum koetjape* (Burm. F.) Merr.	Meliaceae.
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae.
Siniguelas	*Spondias purpurea* Linn.	Anacardiaceae.
Sitao	*Vigna sesquipedalis* Fraw.	Leguminosae.
Squash	*Cucurbita maxima* Duch.	Cucurbitaceae.
Sugar cane	*Saccharum officinarum* Linn.	Gramineae.
Sweet potato	*Ipomoea batatas* (Linn.) Poir.	Convolvulaceae.
Talahib	*Saccharum spontaneum* Linn.	Gramineae.
Tamarind	*Tamarindus indica* Linn.	Leguminosae.
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae.
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae.
Ubgul	*Dioscorea esculenta* (Lour.) Burk.	Dioscoreaceae.
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae.
Upo	*Lagenaria leucantha* (Duch) Rusby.	Cucurbitaceae.
Watermelon	*Citrullus vulgaris* Schrad	Cucurbitaceae.
Yacate (barit)	*Leersia hexandra* Sw.	Gramineae.

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ILLUSTRATIONS

Plate 1

Fig. 1. A typical landscape of Paete clay loam located between the towns of Lumbang and Longos. This hilly and mountainous area is covered with coconut. Lanzones which thrives best in this soil type is grown in-between coconut trees. Commercial and non-commercial forests are also found in this area, especially in the higher elevations.

2. Profile of Paete clay loam in Paete.

Plate 2

Fig. 1. Rice terraces of Luisiana clay loam in the upland between Lilio and Nagcarlan, 700 feet above sea level. Water supply from rain is augmented from streams whose courses have been diverted by farmers.

2. Vigorously-growing upland rice and corn on Lipa loam between Pansol and Calamba. The rolling uplands in the background are of the Macolod clay loam soil type.

Plate 3

Fig. 1. Landscape of Lipa loam in the Canlubang Sugar Estate. This area is devoted to sugar cane. Land preparation is done with farm machinery.

2. A 5-month old cane field of P.O.J. 2878 (fertilized) on Lipa loam in the Canlubang Sugar Estate.

Plate 4

Fig. 1. Crop diversification as demonstrated in the Calauan Experiment Station, Bureau of Plant Industry. Note the luxuriant growth of peanut, upland rice, soy bean, and corn.

2. Cassava "Kamoteng Kahoy" grown between rows of avocado trees on Lipa loam in the Calauan Experiment Station, Bureau of Plant Industry.

Plate 5

Fig. 1. Soybean planted between rows of Citrus on Lipa loam in the Calauan Experiment Station, Bureau of Plant Industry.

2. A lowland rice field on Calumpang clay in Pila.

Plate 6

Fig. 1. Land preparation of Calumpang clay in Calauan. This field is irrigated, hence two crops of rice are raised annually.

2. "Dapog system" of seed-bed preparation common in Bay, Calauan, and Pila on Calumpang clay.

PLATE 7

FIG. 1. Guinangang rice seedlings, 30 days old, just pulled off from its floating bed (Dapog system), ready for transplanting. This practice is common in Bay on Calumpang clay soil type.

2. Rice seedlings, one week after transplanting on Calumpang clay in Bay.

PLATE 8

FIG. 1. An avocado orchard on Lipa loam in the Calauan Experiment Station, Bureau of Plant Industry.

2. Lanzones on Paete clay loam in Paete.

PLATE 9

FIG. 1. Tapping the young inflorescence of coconut for its juice to be made into wine in Rizal. This sight is common in the uplands of Laguna where coconut is grown.

2. Breaking coconuts for copra making in Pila. Note the smoke coming from the nearby kiln.

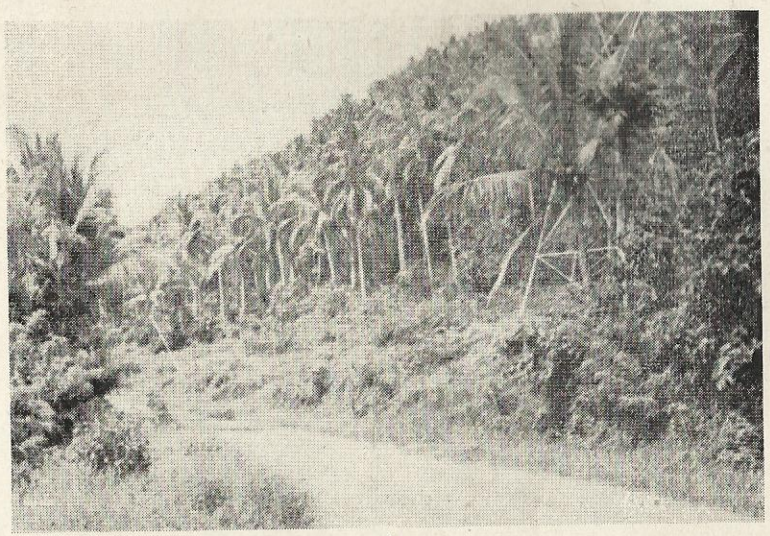

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PLATE 1

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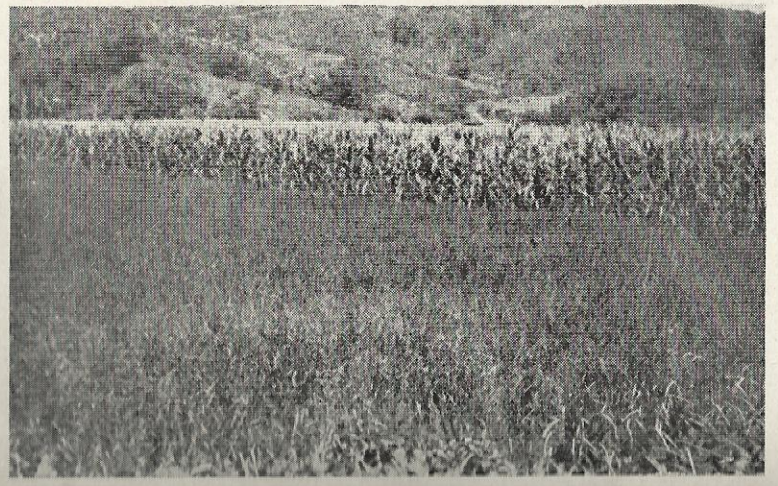

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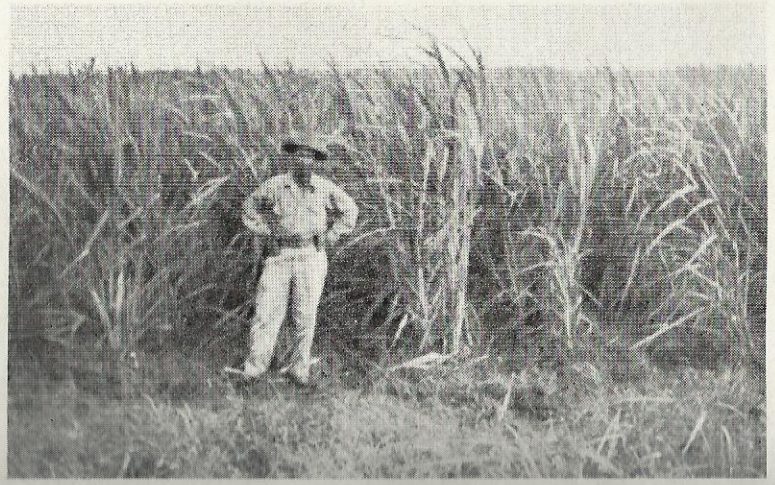

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PLATE I

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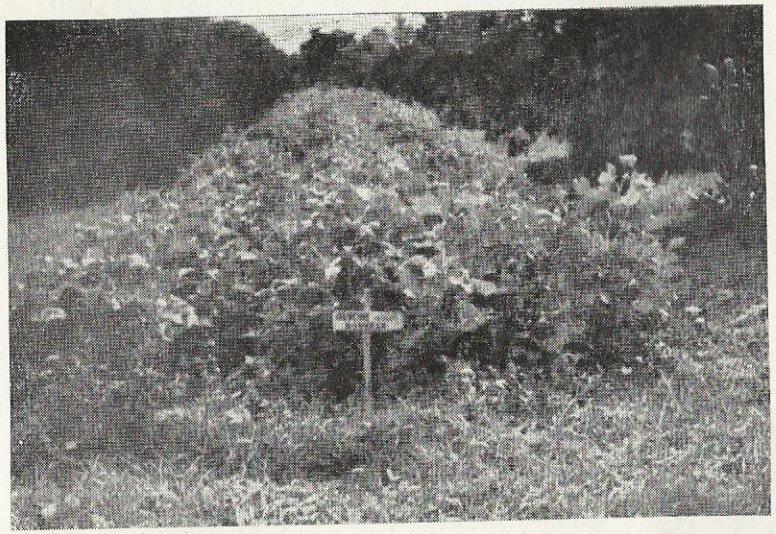
PLATE 1



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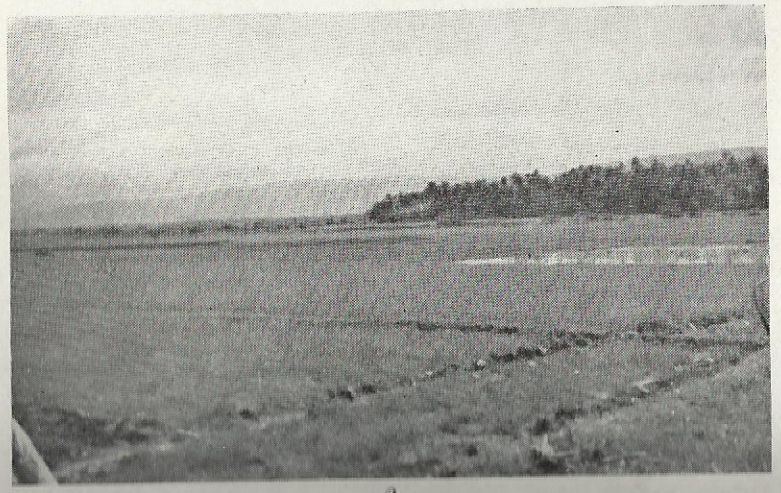

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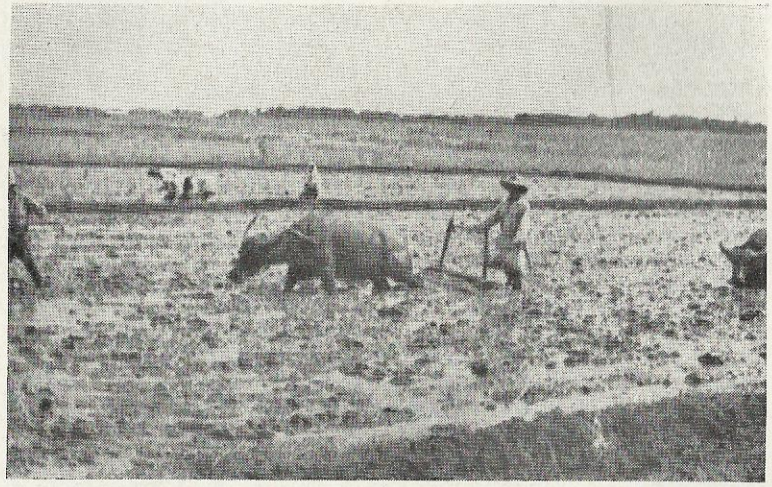

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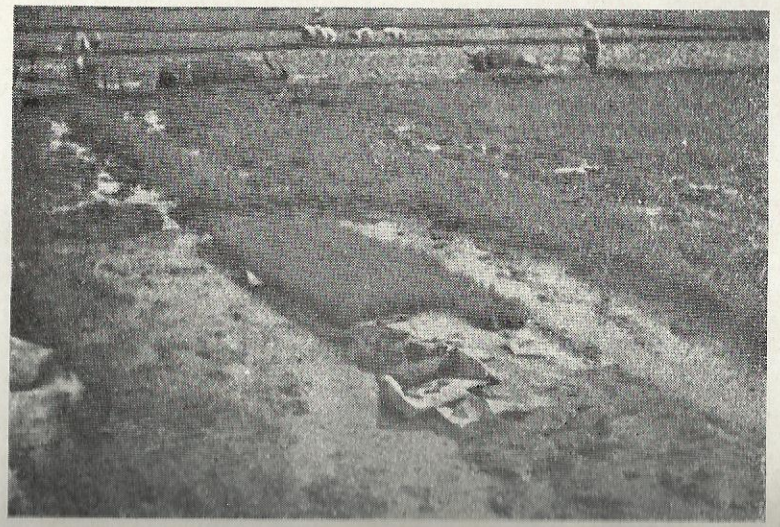

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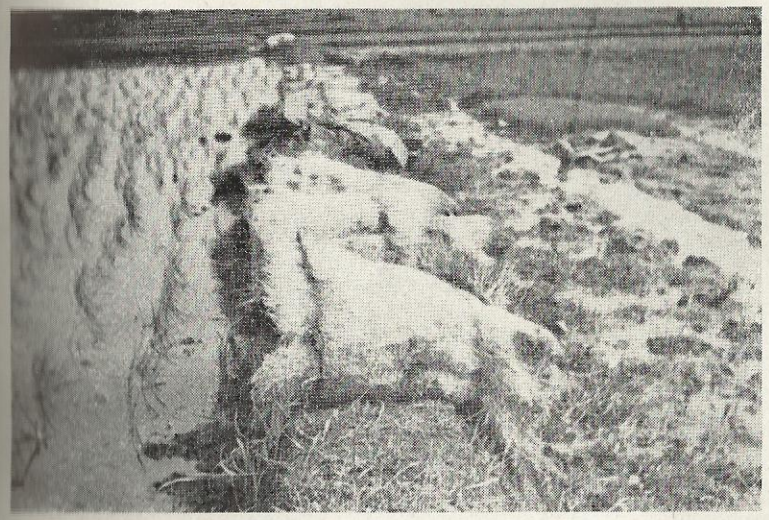

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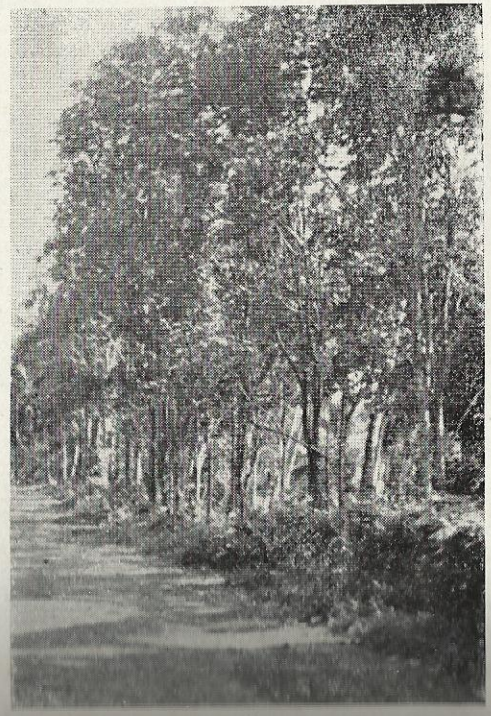

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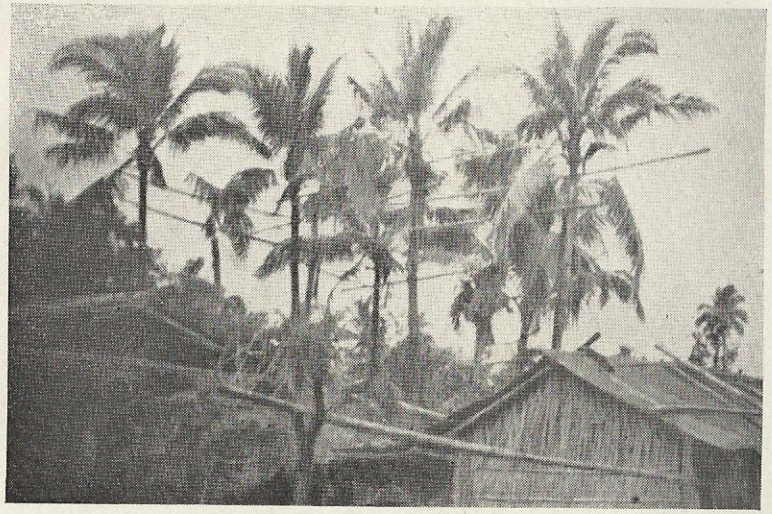

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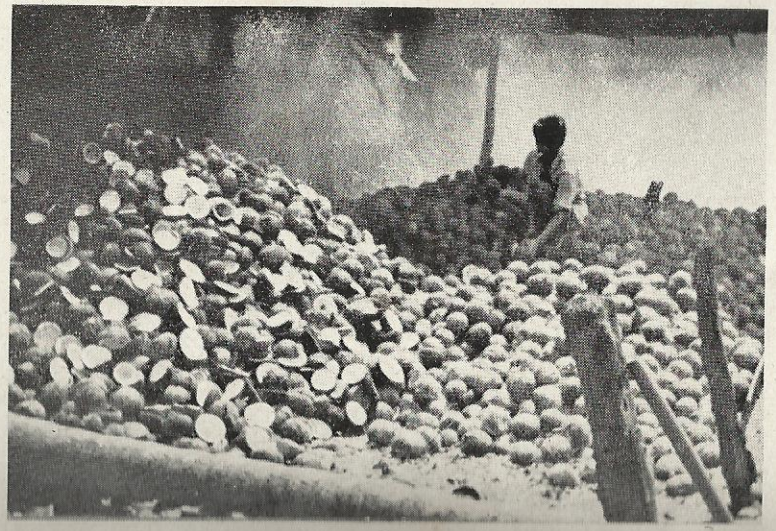

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