REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SOILS
MANILA

Soil Report 38

SOIL SURVEY OF ISABELA PROVINCE

BY

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Members

WITH A DISCUSSION ON SOME CHEMICAL CHARACTERISTICS OF THE SOILS OF ISABELA PROVINCE

BY

Z. P. VENTURA, G. B. QUERIJERO and
R. SAMANIEGO

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SOIL SURVEY OF ISABELA PROVINCE[1]

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[1] Report updated and edited by the Soil Survey Staff, Soils Survey Division, Bureau of Soils.

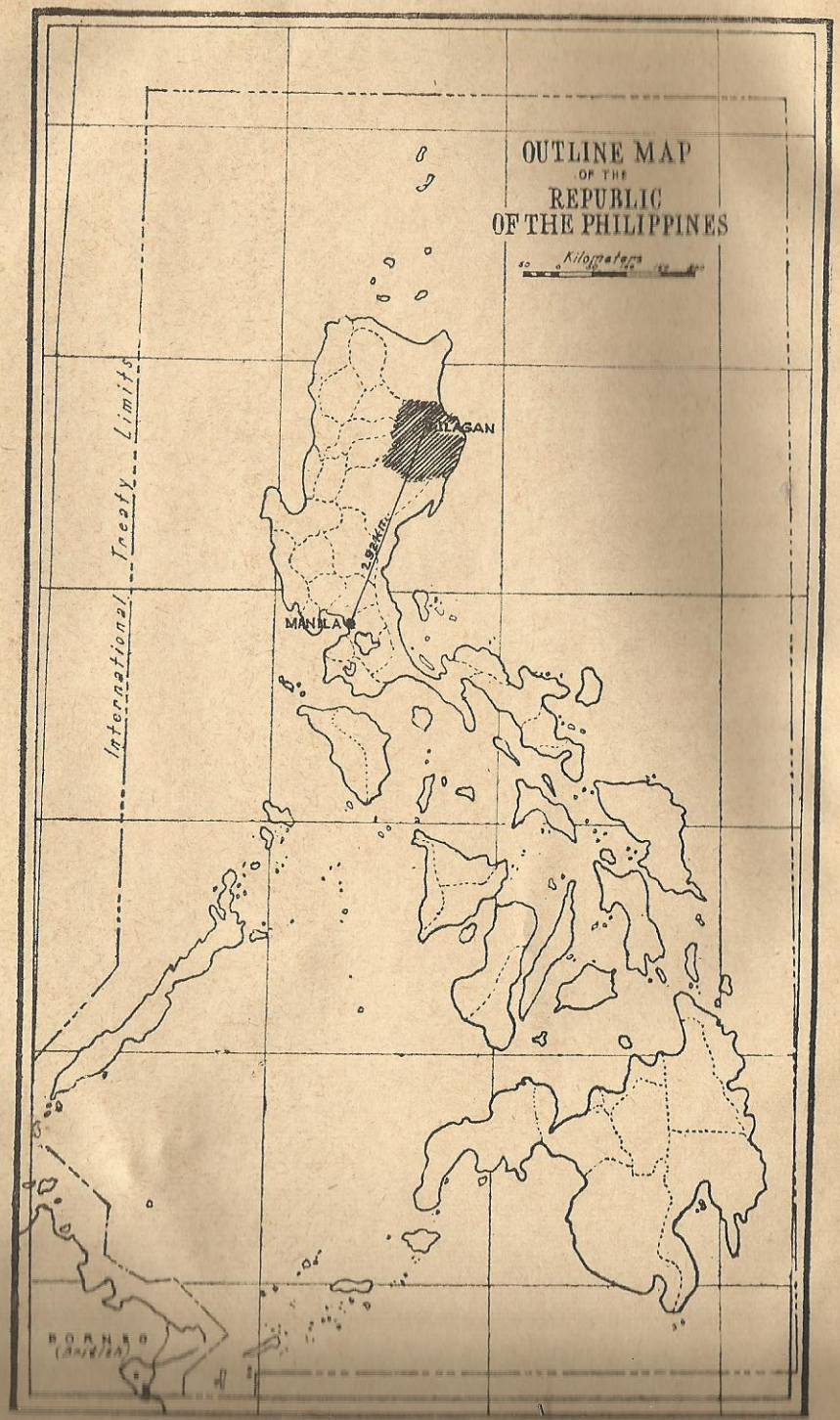

Figure 1. Outline map of the Republic of the Philippines showing the location of Isabela.

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INTRODUCTION

Agriculture is the principal industry in the Philippines and it remains as the main livelihood of millions of Filipinos. Its advancement depends much on the proper conservation of the soil resources of the country. However, much remains to be done to improve our agriculture and to increase the earning capacity of our farmers.

Every year there is a shortage of the staple food crops. The output per hectare of foodgrains is much lower than most other countries. Our soils have been seriously depleted of their plant nutrients and there is a need for replenishment. More and more of the marginal lands and the rolling and hilly terrains have been brought to tillage, so much so that they are not properly utilized and managed resulting in serious soil erosion and low productivity. On the other hand, it is believed that the present area devoted to food crops can be made to produce much more than the need of the population of the country today if the soils are "properly utilized according to the best use that they can be put to."

All these problems come under the scope of Soil Survey, the results of which would serve as a basis for the formulation of a cropping system for each particular type of soil or group of soils. The determination of the physical, chemical, and biological characteristics of the soil, therefore, leads to its proper use and management.

The soil survey of Isabela Province was conducted by the Bureau of Soil Conservation (now the Bureau of Soils) from March 16 to December 14, 1953. The works was greatly facilitated by the financial aid given by the Isabela Provincial Government during the field operations for the maintenance of the vehicle used. In 1962, a survey of the province was made to update or augment the data already compiled.

SUMMARY

Prior to its establishment in May 1856 as a province, Isabela was formerly a part of Cagayan and Nueva Vizcaya Provinces. It has a total area of 1,066,456 hectares. There are at present twenty eight municipalities. According to the 1960 census, the population is estimated at 442,062. Ilagan, the capital, is 292 air kilometers northeast of Manila. Ilagan is linked with Manila by the National Highway via Sta. Fe. By this highway the distance between these two points is about 410 kilometers.

Isabela occupies the upper part of the Cagayan Valley which is flanked by the Sierra Madre Mountains on the east and by the range that traverses Ifugao, Bontoc and Kalinga on the west. The high peaks found within the provinces are Mount Dos Cuernos (1,784 meters), Mount Cresta (1,670 meters), Mount Palanan (1,212 meters), and Mount Moises (1,240 meters). The province is well drained by the Cagayan River and its various tributaries. Rivers in Isabela provide waterways to places outside of the province most notably Aparri, Ifugao, Bontoc, and Kalinga.

The climate is very favorable to the growth of tobacco, rice, corn, fruits, vegetables, root crops, citrus, sugar cane and coffee. There are two types of rainfall distribution in the province, namely, the third and fourth types. The third type, characterized by not very pronounced maximum rain period with a short dry season, prevails over the central and western sides of the province; the fourth type, which has no pronounced maximum rain period and no dry season, covers the eastern part of Isabela wherein the lone town of Palanan is situated.

The province possesses vast forest resources. In 1957 in the Caraballo and Sierra Madre Mountains an estimated area of 521,500 hectares of commercial forest existed which had an approximate standing timber of about 35,670,600 cubic meters. Wide grasslands also exist in several places and most of these are utilized for pasture. In addition to forests and grasslands fish and game animals abound.

Tobacco was the most important crop in Isabela during the Spanish regime when the Philippines had the monopoly of the

tobacco trade with Spain. The agricultural census in 1960 shows that tobacco ranks third to palay and corn in money value. The other crops grown extensively are peanut, banana, mongo, pineapple, mango, root crops, beans, coffee and cacao. Banana is the leading fruit crop in the province but coffee has recently been gaining ground as a money earner for the province so much so that hills have been cleared to plant coffee trees.

According to census figures of 1960, there were 56,755 farm units covering about 213,487.5 hectares. Full owners total 23,110 with a corresponding hectarage of 99,347.7 under their control; part owners number 9,310 with 38,688.9 hectares under their operation; tenants of different categories number 23,672 in all and they account for 59,811.6 hectares under cultivation; managers number 100 and under their management are 11,741.4 hectares; and finally are 564 operators of various classifications other than those already specified and who account for 3,897.9 hectares under their control.

There are twenty-one soil types and three miscellaneous land types delineated in Isabela. Four soil types found in the plains have good drainage while six soil types also in the plains are poorly drained. The well drained soils developed from recent alluvial deposits are Quingua sandy loam, Quingua silty clay loam, San Manuel loam, and San Manuel sandy loam. The poorly drained soils developed from recent alluvial deposits are Bantog clay loam, Bigaa clay and Sta. Rita clay loam. The Bago series, also of the plains and with generally poor drainage, was developed from older alluvial deposits. The clay loam and sandy clay loam types are nearly level or level in relief which partly accounts for their poor drainage. On the other hand, the Bago sandy loam with a relief which ranges from nearly level to undulating has fair to good external drainage.

Eleven soil types belonging to six soil series were classified in the rolling uplands of the province. The Alaminos series was developed from basalts and andesites, poorly drained internally, and is rolling to hilly with some level areas; the Cauayan series was developed from older alluvial deposits, poorly to fairly drained internally, and is undulating to rolling; the Guimbalaon series was developed from basalts and andesites, has fair to good internal drainage, and has rolling to hilly relief; the Ilagan series was developed from sandstone, poorly

drained internally, and is rolling to hilly; the Rugao series was developed from older alluvial deposits, has poor to fair internal drainage, and has either rolling or undulating relief with some level portions; finally, there is the San Juan series which was developed from older alluvial deposits, poorly to fairly drained internally, and hilly in relief.

The soils found in the rolling uplands are best suited to pasture. Those in the steeper areas adjoining the mountain ranges of Mountain Province and Sierra Madre are covered with non-commercial and commercial forests and should best remain under forest. The soil types classified as class A land are Quingua sandy loam, Quingua silty clay loam, San Manuel loam and San Manuel sandy loam. Class A land can be cultivated safely and requires only simple but good farm management practices. Alaminos clay loam falls under Class B and with erosion as the main problem. As the slope of the land becomes steeper erosion consequently becomes more problematic, thus this soil type also assumes a lower class rating such as class M which in terms of land use is best suited for pasture or forest. Soils of the Bago, Bantog, Bigaa, and Sta. Rita series also fall under class B land but the main problems encountered in these soils are wetness and drainage. Beach sand which is a miscellaneous land type is under sub-class Ds which means that the area has a very low fertility, very rapid permeability, and low moisture holding capacity. Hydrosol areas are under class X which means that they are wet most of the time and being uneconomical to drain are best suited for fish ponds or for recreation. Mountainous areas are under class Y and should be reserved for recreation and wildlife.

The productivity ratings of each soil type for the principal crops grown under common practices without the use of fertilizers or soil amendments are tabulated for guidance purposes. This report also contains the chemical analyses of soils in the province. The fertilizer and lime requirements of the different soil types, the pH values and the available plant nutrient elements in parts per million are shown in different tables.

A glossary of common economic plants with their corresponding scientific names are found at the end of the report. A soil map accompanies this soil report.

SOIL SURVEY OF ISABELA PROVINCE, PHILIPPINES

DESCRIPTION OF THE AREA

Location and extent.—Isabela is one of the three provinces found in the Cagayan Valley. It is bounded by Cagayán Province on the north; by Nueva Vizcaya Province on the south; by the Mountain Provinces on the west; and, by the pacific Ocean on the east. The province is accessible by highways; from the south through Cabanatuan and from the north through Aparri. Transportation to some places in Isabela are by air and water; Palanan, an interior town in the Sierra Madre, can be reach by light plane from Cagayan or Aparri and by motor boat from Aparri and Baler. The Philippine Air Lines also serves the province through the airport located in Cauayan. Ilagan, the capital of the province, is 410 kilometers from Manila through the National Highway. The province has an area of 1,066,456 hectares.

Relief and drainage.—Isabela is in the middle part of the Cagayan Valley. The flood plains of the province are along the Cagayan River and its big tributaries. One big plain, the Mallig Plain, is in the northwestern part of the province. The western part of Isabela is hilly and mountainous. The eastern side consists of a series of mountains called the Sierra Madre Range.

In general, the land tilts downward from the north and the south and from the east and the west towards the middle part of the province. The high peaks in the Sierra Madre Range are Mount Dos Cuernos (1,784 meters), Mount Cresta (1,670 meters), Mount Moises (1,240 meters), and Mount Palanan (1,212 meters).

Isabela also occupies the central portion of the watershed of the Cagayan River. The Cagayan River traverses the entire province from south to north cutting it into two segments with the one on the east being twice as large as the other on the west. The main tributaries of this river are the Ipil, Magat, Siffu, and Malllig Rivers on the western side and the Diboluan, Ilagan, and Pinacauan de Tumauini Rivers on the eastern side. The eastern coastal areas drain to the Pacific Ocean.

During the latter part of the year surface runoff caused by heavy rains in the upper parts of the Cagayan River watershed swell the big rivers into overflowing their banks thereby affecting the bottom lands.

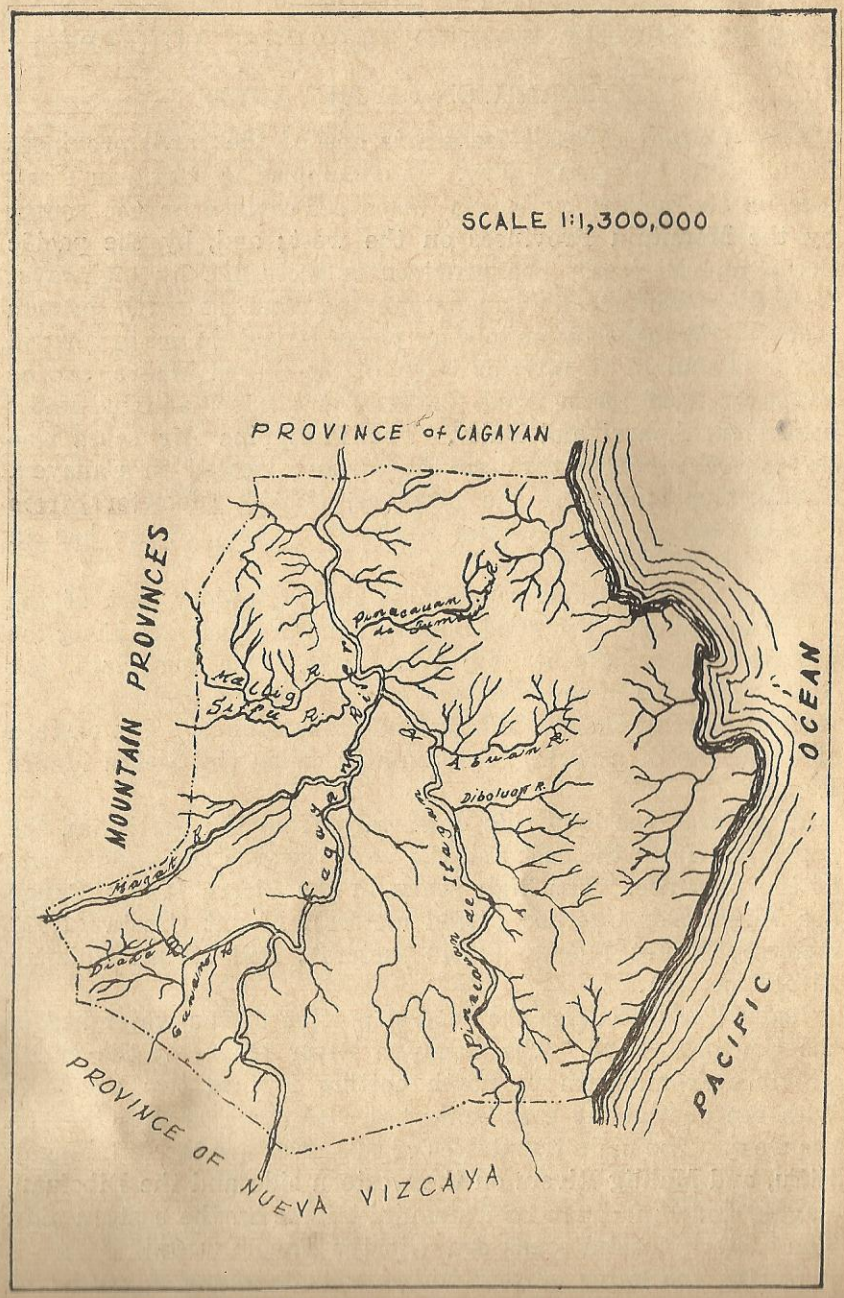

Figure 2. Map showing drainage pattern of Isabela Province.

Figure 3. A view of a portion of the wide plains through which the Cagayan River winds its course in Isabela.

Figure 4. Denuded and sparsely vegetated hills common in the province.

Geology.—Alluvium comprises most of the areas along the Cagayan River. Underneath this alluvium are Batan and Vigo formations of the middle Miocene epoch. The rolling lands and hilly places along the Cagayan River are of marine and terrestrial sediments associated with reef limestone and pyroclastic materials. There are also marl and reworked tuff in some places. Sporadic terrace gravel deposits are found in coastal and fluvial tracts. In some elevated flat land surfaces are plateau red earths. Near Palanan, the hills are of igneous origin made up of diorites, gabbros, peridotites, etc., which extend up to Mount Moises and Mount Cresta. South of Palanan and running along the coastal areas, the hills are of limestone formation known as Ibulao limestone which is generally massive and fossiliferous and about 200 meters thick. This formation extends to the south of Jones. The formation about Ilagan is known as Ilagan sandstone composed of poorly cemented sandstones of from 200 to 400 meters thick. This formation is also fossiliferous of the Tertiary Lower Zone.

Vegetation.—The vegetation of the province may be grouped into three types; namely, forest, grass, and cultivated crops. The forest consists of primary and secondary forests. The greater part of the eastern side of the Sierra Madre Range is covered with primary forest of good quality timber such as *guijo,* white and red *lauan, bagtican, apitong, tanguile, mayapis* and *narra.* Many rolling areas in the western and central parts of the province are grasslands generally used for pasture. These grasslands are, however, covered mostly with poor quality grass. The most common grasses are cogon, talahib, and several species of Cyperus plants. The principal cultivated crops are rice, corn and tobacco.

Transportation.—Ilagan, the capital of the province, is 410 kilometers from Manila by the north national highway. This same highway, passing through Tuguegarao and Aparri, Cagayan Province, connects Isabela with the Ilocos Provinces. Several transportation companies operate passenger and freight trucks throughout the province. All towns in Isabela except Palanan are connected by first or second class roads. Palanan is quite isolated, served only by a 45-kilometer trail which crosses the Sierra Madre Mountain Range. The town can also be reach by boat either from Aparri, Cagayan Province, or from Baler, Quezon Province; or by light plane from the Cauayan Airport, Cauayan, Isabela.

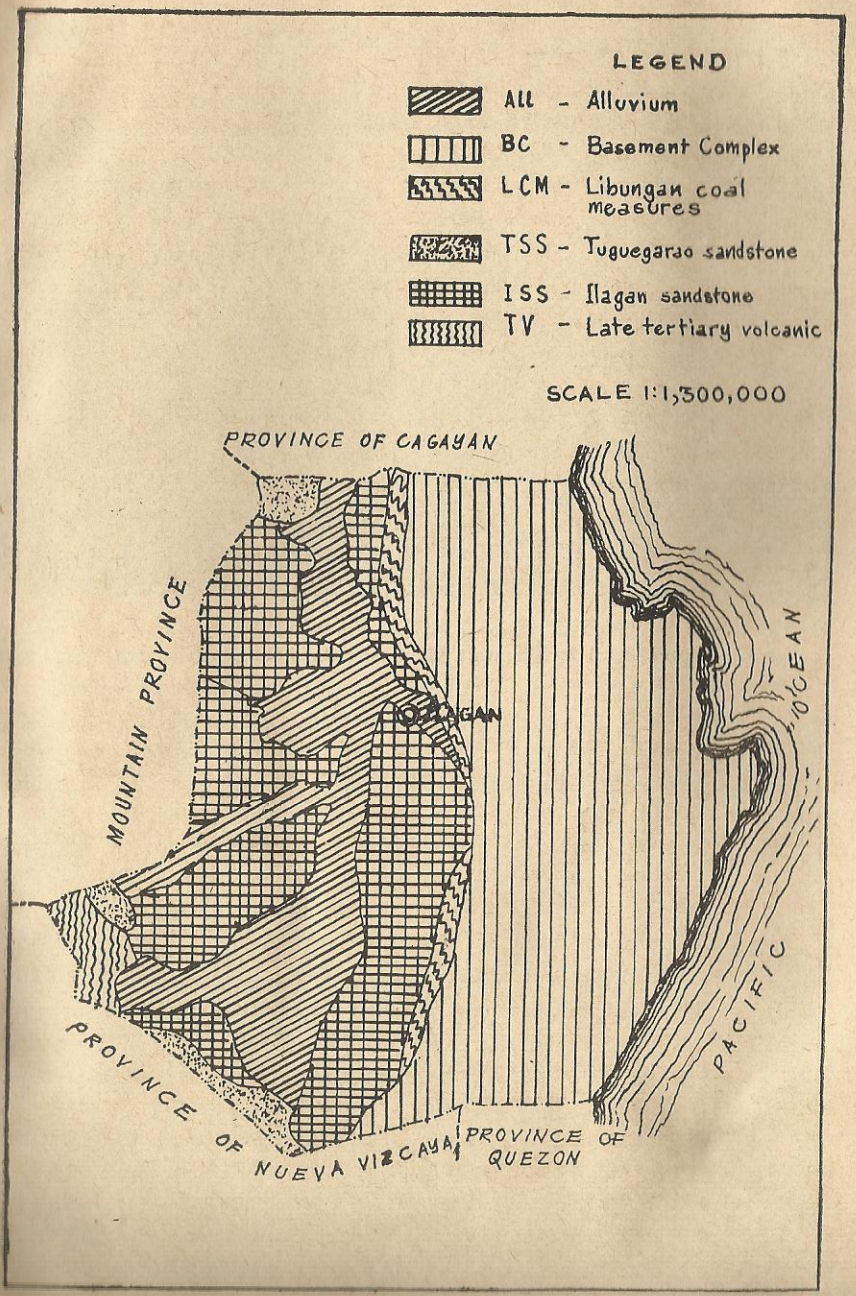

Figure 5. Geological map of Isabela Province.

Figure 6. The formation of Cagayan Valley has reached a stage of maturity as evidenced by the wide plain on both sides of the river.

Figure 7. A view of the Cagayan River at a ferry crossing where vehicles are transported across the river.

Industries.—Farming is the principal industry of the province. Rice, corn, and tobacco are the principal cash crops, in the order mentioned. In 1960 the total area devoted to farming was 213,487.5 hectares. Almost 70 per cent of the total farm area is devoted to palay production while the rest are devoted to various crops.

In the livestock industry, cattle raising is the most important. Most of the pasture areas are located in the central and western parts of the province. In 1960 the total value of livestock raised in the province was 40,160,596 pesos. Poultry raising is also a thriving industry. The 1960 census recorded the total value of poultry at 1,392,688 pesos.

The province is also very rich in timber. In 1949 timber production was 14,413.9 cubic meters. In that year there were 11 sawmills in operation with a total daily capacity of 81,000 board feet. There was a little decline in production in 1952. With the same number of sawmills operating the production was only 11,099.7 cubic meters. However, in 1955 lumber production went up to 14,641.2 cubic meters with 12 sawmills operating and in 1958 some 16,955.7 cubic meters were produced.

Organization and population.—The province of Isabela was created in May 1856, out of areas from Cagayan and Nueva Vizcaya. Prior to its creation the towns of Camarag, Angadanan, Nagali, Gamu, and Ilagan were already centers of religious missionaries. During the Silang Rebellion in the Ilocos Region, some sections in Isabela were aroused and they too revolted led by Dabo and Juan Marayac. Another rebellion in 1785 was led by Labutao and Baladon. In 1898, during the Philippine revolution, the province came under the control of the revolutionists led by Colonel Daniel Tirona. During the latter part of the Philippine independence movement when the American forces were fighting against the Filipinos, General Aguinaldo established his headquarters and made his last stand in Palanan. Tricked by some Macabebes from Pampanga, whom General Aguinaldo thought were part of the reinforcement he asked, he was treacherously captured in Palanan in March 1901. Civil government was established in the province on August 23, 1901.

The population of Isabela has constantly increased. The population of 76,431 in 1903 gradually increased until it reached 442,062 in 1960. Prior to 1940, the big plain of Mallig was sparsely settled, but when the National Land Settlement

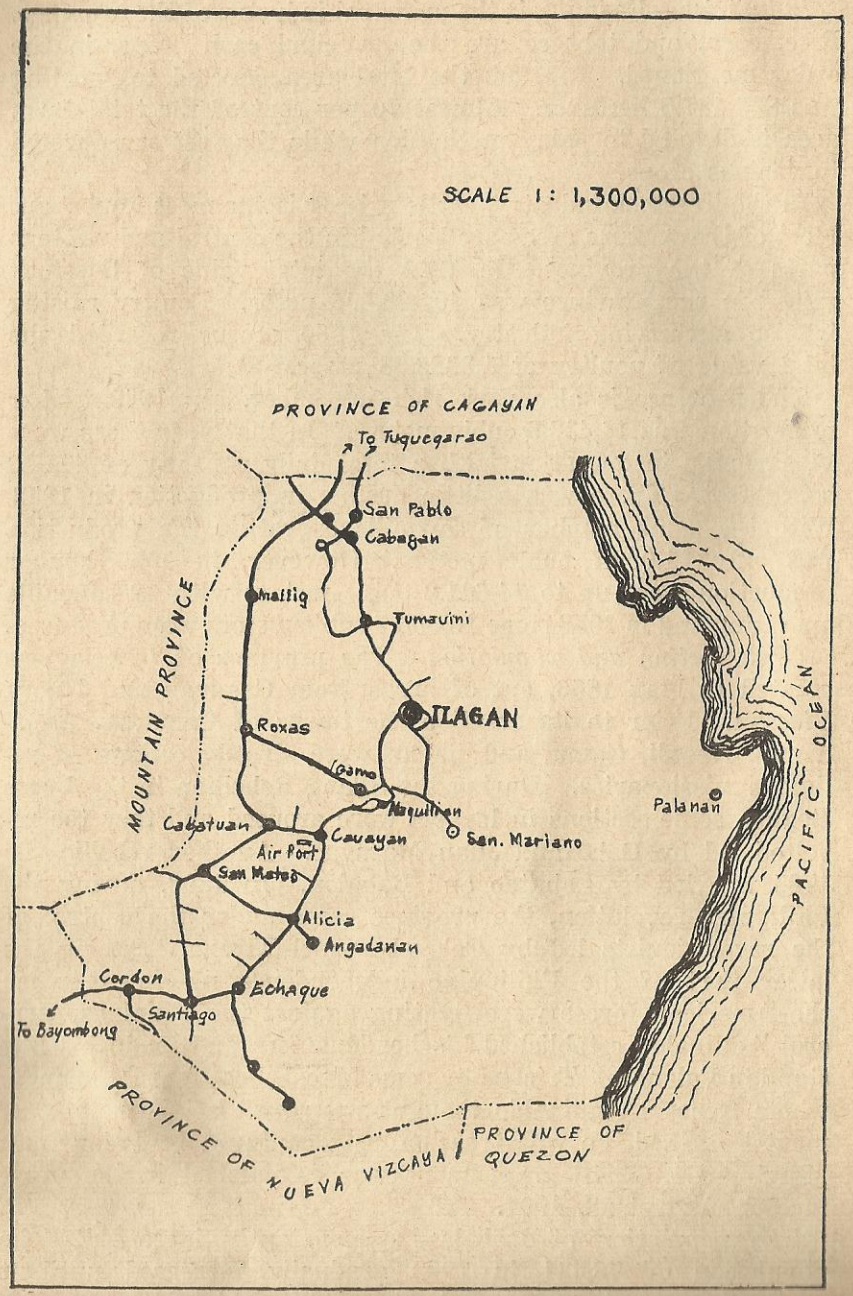

Figure 8. Map showing road system of Isabela Province.

Figure 9. A few progressive farmers mostly on the plains practice crop rotation. Note the wide plain planted to mongo after rice.

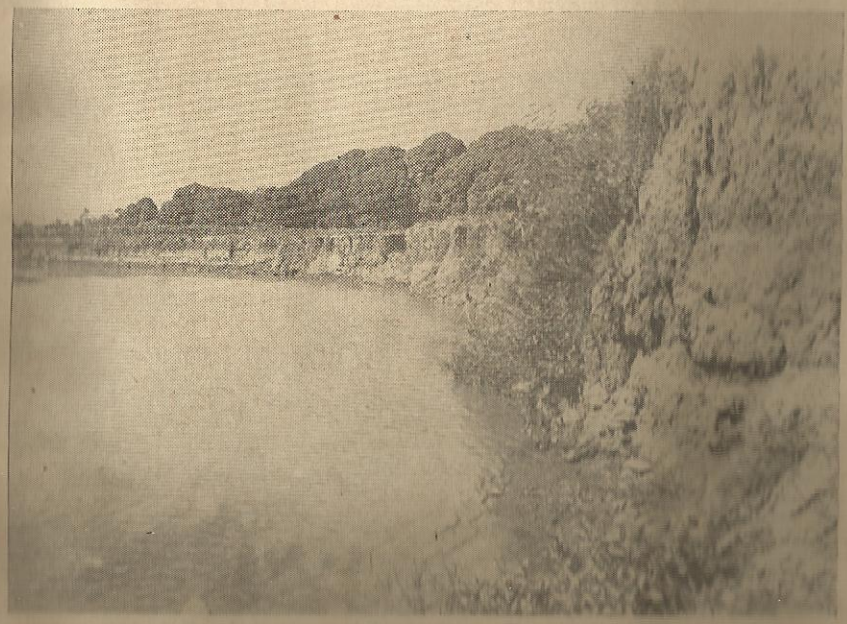

Figure 10. A stretch of the Cagayan River. This river is a potential source of irrigation for the province.

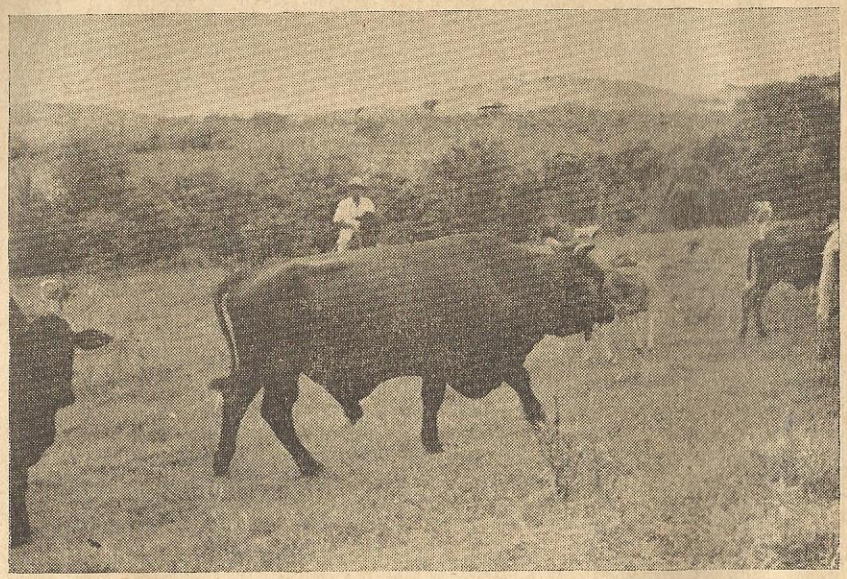

Figure 11. Cattle raising is an important industry in the Province. The wide expanse of grasslands favors a wide development of ranching.

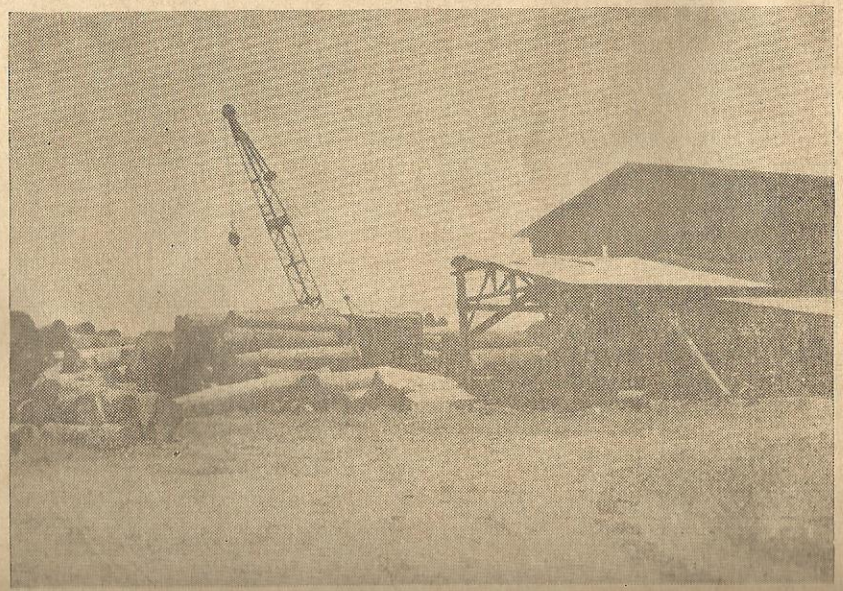

Figure 12. The lumber industry is another big enterprise which is a good source of income in the province.

Administration opened a settlement site there, the number of people increased until the place became a regular municipality. During the 1960 census the density of population in the whole province was recorded at one person for every 2.41 hectares. This apparently large area per person is attributed to the large area occupied by the Sierra Madre Range which is not habitable but was included in the population density estimate.

CLIMATE

Climate is predominantly responsible for the classes of fauna and flora that thrive naturally on any part of the globe. It determines or delimits the kinds of agricultural crops which can be grown economically and profitably in any given place. In effect, therefore, climate is of primary significance to agriculture. Elements of climate like temperature, water supply (precipitation), humidity, sunshine, cloudiness, light, wind, storms, and salt spray are interrelated in their influence on plant and animal life.

Plant is a complicated organism, affected by nutritional and climatic environment, the effects of which influence plant response either favorably or adversely. The risk in farming will be considerably minimized and precarious economic returns of living from the soil can be more or less stabilized if only a farmer can, in some way, predict with a certain degree of accuracy what weather conditions will be for the coming year, an ensuing season, or even in a month. The quality of produce especially of vegetables, the ravages of insects and plant diseases, defoliation, fruit and root troubles are some aspects of crop production which are brought about directly or indirectly by climatic elements.

The climate of an area is the summation of weather from day to day, and weather is a day-by-day breakdown of climate. Meteorologists therefore, are concerned with the daily weather while climatologists concentrate on the longer time range.

There are two types of climate in Isabela Province, namely, the third and the fourth types.

The third type is characterized by no very pronounced maximum rain period with a short dry season lasting from one to three months. In this type, rainfall starts in July and continues through December with either October or November as the peak of the rainy season. This type covers the central and western

parts of the province. The annual average rainfall recorded in Ilagan within a 25-year period was 73.04 inches.

The fourth type of climate is characterized by no pronounced maximum rain period and no dry season. This means that rainfall is more or less evenly distributed throughout the year. This type covers the eastern part of the province. Only one town, Palanan, is found in this section of the province. In the absence of weather data in Palanan, those of Casiguran, Quezon Province, a town south of Palanan, are presented for discussion. The average annual rainfall in Casiguran recorded within a 14-year period was 142.44 inches. The rain period is from September to December with the latter month registering 20.82 inches. April has the least rain with only 6.54 inches.

The monthly distribution of rainfall for the third and fourth types of climate are shown in table 1.

Temperature in the Philippines does not vary much from place to place except in places of relatively high altitudes. In Isabela, the hottest month are from April to August. The temperature in April is usually 82.4 degrees Fahrenheit (28.0 degrees Centigrade) while the mean maximum temperature within the period reaches up to 84.38 degrees Fahrenheit (29.1 degrees Centigrade). As usual the approach of the cold months tones down the temperature to 75 degree Fahrenheit (23.8 degrees Centigrade), which is the average for January.

The effects of typhoons upon the weather in the Philippines are of great significance. One important aspect is the amount of rainfall a typhoon brings. Where typhoons come in quick succession, disastrous floods may follow.

Isabela is located in an area which is very frequently traversed by strong typhoons. The records between 1903 and 1918 show that a total of 13 typhoons or about 21.7 per cent of the typhoons in the Philippines within the said period, passed through Isabela. This high frequency of occurrence is attributed to the geographical location of the province. One characteristic of typhoons here in the Philippines is that they originate from the Pacific Ocean and move westward towards the Philippines usually swerving northward as they reach the eastern coasts of the Islands. In this northerly direction of the paths of typhoon provinces in Northern Luzon are the ones generally affected.

The prevailing winds in the Cagayan Valley come from the south from June to October; from the northeast from November to May.

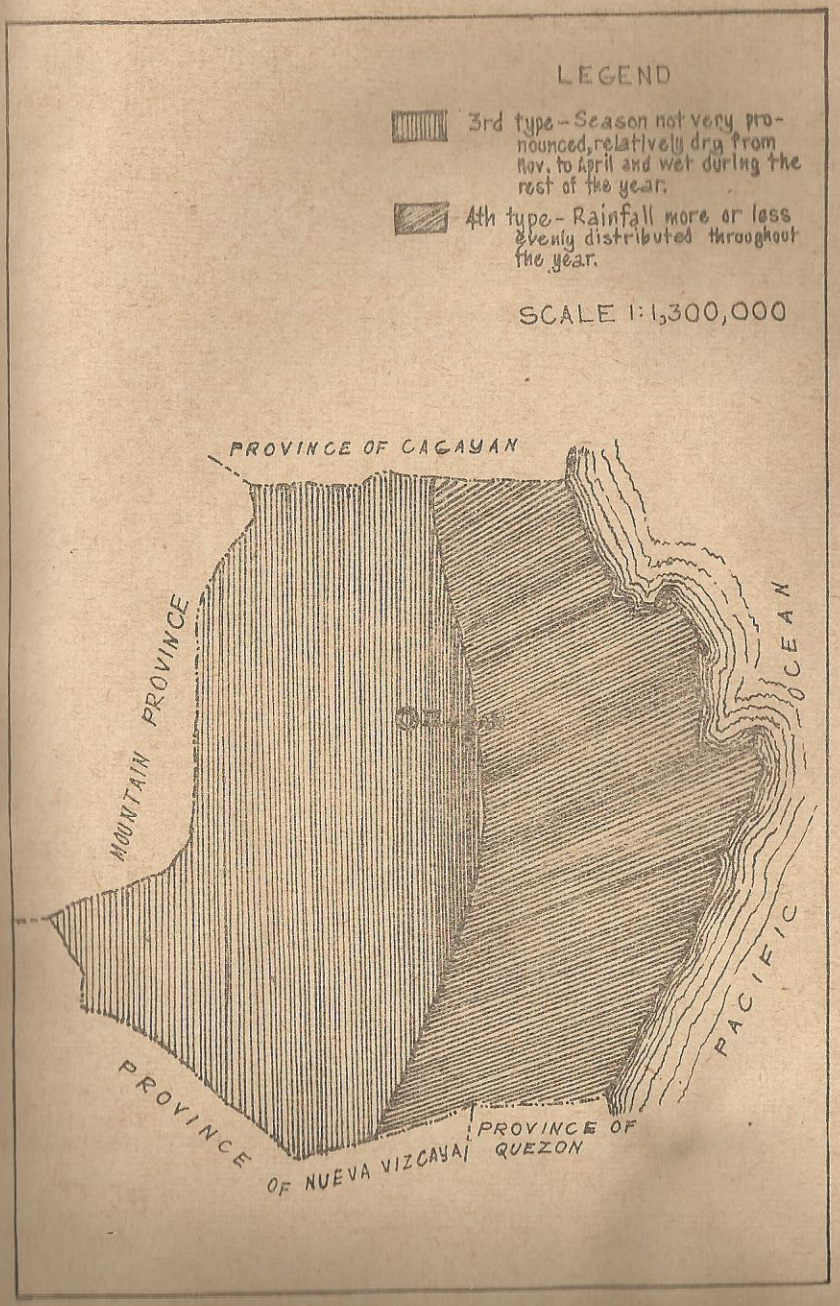

Figure 3. Climate of Isabela Province.

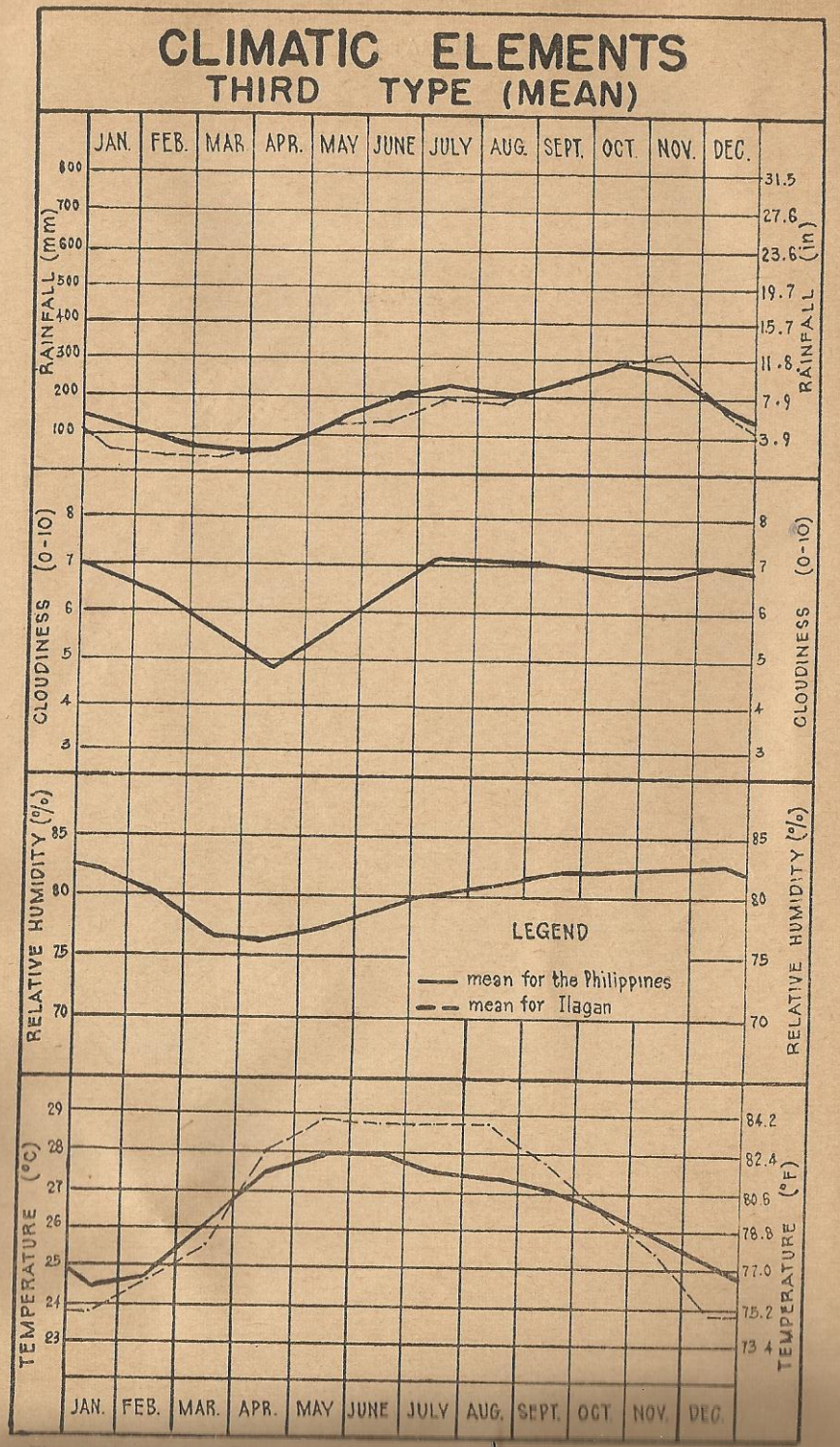

Figure 14. Graph of the third type of climate of the Philippines, and of Ilagan, Isabela.

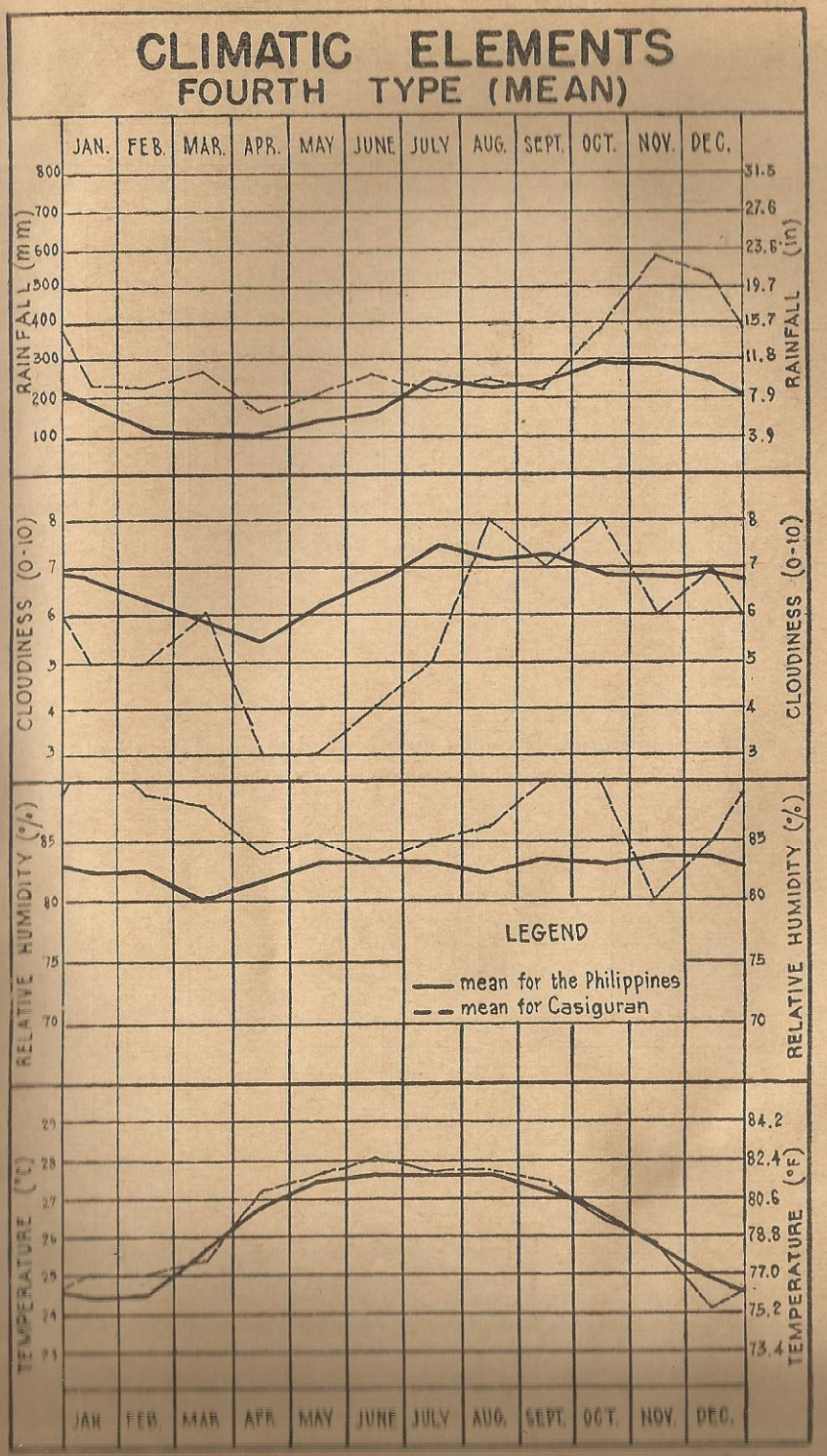

Figure 15. Graph of the fourth type of climate of the Philippines, and of Casiguran,

TABLE 1.—*Monthly average rainful and rainy days recorded in Ilagan, Isabela, and in Casiguran, Quezon.*[1]

Station Years of record	Third type of climate Ilagan, Isabela 25 years		Fourth type of climat Casiguran, Quezon 14 years	
Month	Rainfall (Inches)	Number of rainy days	Rainfall (Inches)	Number of rainy days
January	2.32	11	9.08	18
February	1.76	7	8.84	16
March	1.64	6	10.57	17
April	2.36	6	6.54	15
May	4.89	10	7.93	18
June	5.44	11	10.15	16
July	7.66	13	8.49	16
August	7.25	13	9.63	18
September	9.78	14	12.73	19
October	11.30	16	14.85	19
November	12.11	17	22.81	18
December	6.53	15	20.82	21
Annual	73.04		142.44	

[1] Weather Bureau "Monthly Average Rainfall and Rainy Days in the Philippines," (Manila: Weather Bureau, 1962). (Mimeographed.)

TABLE 2.—*Temperature in Ilagan, Isabela; and temperature, mean relative humidity, and mean cloudiness in Casiguran, Quezon.*

Station	Third type Ilagan, Isabela[1] (Hda. Isabel)	Fourth type of climate Casiguran, Quezon Year of record—1954				
	Temperature	Temperature			Relative humidity mean (Percent)	Cloudiness mean (0-10)
Month	(Fahrenheit)	Mean	Mean maximum	Mean minimum		
		(Fahrenheit)				
January	75.0	77.0	85.8	68.1	93	5
February	76.6	77.0	86.1	68.0	89	5
March	78.2	77.8	86.0	69.6	88	8
April	82.4	81.0	90.9	71.1	84	6
May	84.0	81.8	91.6	72.1	85	4
June	83.9	82.5	92.2	72.8	83	3
July	82.8	82.0	91.2	72.8	85	5
August	82.6	82.0	90.4	73.5	86	3
September	82.2	81.4	90.3	72.4	90	7
October	80.0	79.7	88.1	71.3	90	8
November	77.8	78.4	86.5	70.2	80	6
December	75.6	75.5	82.2	68.8	85	7
Annual		79.7	88.4	70.9	86	6

[1] Data taken by the authors from records of weather station Hda. Isabel, Ilagan, Isabela. Data for other climatic elements not available.

[2] Weather Bureau, *Annual Climatological Review: 1954*, (Manila: Weather Bureau. 1956), p. 142.

AGRICULTURE[1]

Isabela is an agricultural province and a great number of its people derive their livelihood from farming. The development of farming had its early start during the Spanish regime when such old Spanish corporations like the Compania General de Tabacos de Filipinas established farms in this province to supply the trade with Spain.

Although tobacco is a very well known product associated with the Cagayan Valley, census figures of 1960 showed that rice is the most important crop in Isabela both in production and in value. Tobacco ranked third in importance.

CROPS

The ten leading economic crops of Isabela, with their corresponding area planted, production in cavans or kilograms and value in pesos are as follows:

Crop	Area–hectares	Production	Value
Palay—			
Lowland:			
1st crop	91,880.8	2,931,809 Cavans	₱29,580,994
2nd crop	4,462.1	135,544 Cavans	1,095,605
Upland and *kaingin*	16,536.5	350,606 Cavans	2,795,462
Corn:			
1st crop	33,030.9	595,982 Cavans	4,916,170
2nd crop	12,791.2	179,695 Cavans	1,189,490
3rd crop	7,57717	107,984 Cavans	602,847
Tobacco:			
Native	18,600.0	8,785,408 kg.	₱5,614,922
Virginia and other varieties	43.4	23,888 kg.	40,791
Peanut	6,225.5	4,206,676 kg.	1,419,614
Banana	2,286.5	8,948,545 kg.	715,758
Mongo	1,999.1	1,052,884 kg.	663,566
Pineapple	238.8	3,577,556 kg.	488,880
Mango	292.5	410,195 kg.	148,411
Camote	264.4	1,059,748 kg.	110,174
String beans	629.5	292,109 kg.	109,610

Palay.—This crop is extensively grown in the province. The municipalities leading in rice production as of 1960 are San Mateo, Santiago, Roxas, Echague, Alicia, Gamu, Cauayan, Magsaysay, Callang, and Ilagan. Rice is the staple food of the people.

[1] Agricultural data taken mostly from the Bureau of the Census & Statistics publications unless otherwise specified.

Both upland and lowland rice cultures are done. Upland rice covers an area of 16,536.5 hectares giving a yield of 350,606 cavans of palay. Under the lowland culture, rain-fed and artificial irrigation systems are used. In 1960 a total area of 91,880.8 hectares was planted to lowland rice, first crop, with a total yield of 2,931,809 cavans of palay. The second crop covering 4,462.1 hectares gave a yield of 135, 544 cavans of palay. Lowland rice is usually planted from August to September and harvested in November to as late as February. Some of the varieties grown are Raminad Strain III, which yields about 66 cavans of palay per hectare in irrigated areas; Intan, which yields about 35 cavans, and Elon-eloh which yields from 10 to 20 cavans of palay per hectare.

There are two irrigation systems existing in the province, namely, the Magat River Irrigation system serving 23,500 hectares between Santiago and Cauayan, and the Siffu River Irrigation system covering 18,000 hectares in Aurora and Roxas. In addition, there are 12 commercial irrigation systems covering 600 hectares, 3 private irrigation systems covering 1,000 hectares, and 5 pumps for irrigation purposes. These irrigation systems help increase the rice production in this province and if proper soil management is practiced rice yields could go higher.

Corn.—Corn is the second crop in importance. It is grown throughout the year with two to three crops annually. During an extended drought, it is planted only once or twice a year. In 1960 the total area planted to this crop was 53,399.8 hectares with a total production of 877,661 cavans of shelled corn valued at ₱6,211,507.00.

The ten leading towns in corn production as of 1960 are Ilagan, Cabagan, Tumauini, Echague, Gamu, Sto. Tomas, Jones, Roxas, Reina Mercedes, and Angadanan. The yield ranges from 13 to 21 cavans of shelled corn per hectare.

Corn production is very poor due to low soil fertility. The usual practice is to grow corn successively on the same field several times a year without the use of fertilizers. Fairly good production is maintained in some of the bottom lands due to the effect of the seasonal floodings of the Cagayan River.

Figure 16. The flat lowlands are used for lowland rice culture during the rainy season. In some cases, a second crop of rice may follow but usually tobacco is planted instead.

Figure 17. The Magat River Irrigation System assures a constant supply of water for rice fields as well as for second crops after rice.

Figure 18. Corn is another important crop in the province. It is planted the year round on the well drained alluvial soils or as a second crop after rice.

Figure 19. Pineapple growing is very popular in Alicia and in the surrounding towns. Fruits are mostly for local consumption.

Tobacco.—The crop is grown on the alluvial plains after the harvest of either rice or corn. Planting is done in October or November and harvested in January or February. The important varieties grown are Simmaba, Espada, Vizcaya and Pampano—all are filler-type tobacco. The yield ranges from 10 to 20 quintals per hectare.

The principal tobacco areas are Ilagan, Cauayan, Aurora, Gamu, Reina Mercedes, Alicia, Cabagan, Roxas, Jones, and San Pablo.

Beans and Peas.—Peanut, mongo, and other legumes constitute this class. In 1960 the area planted to peanut was 6,225.5 hectares producing 4,206,676 kilograms valued at 1,419,614 pesos. Mongo covers an area of 1,999.1 hectares with a total production of 1,052,834 kilograms valued at 602,566 pesos.

These two crops, like tobacco, are planted as second-season crop. The towns of Tumauini, San Agustin, Echague, Magsaysay, Aurora, Sto. Tomas, Sta. Maria, San Mariano, and Cauayan are the principal producers of mongo. Angadanan, San Agustin, Jones, Sto. Tomas, Echague, Sta. Maria, and Cauayan lead in the production of peanut.

Fruit trees and other cultivated fruits.—The production of these crops is not as important as the other food crops. The principal fruit trees grown are banana, pineapple, mango, papaya, orange, starapple, avocado, mandarin, and jackfruit. The number of bearing trees or hills, total number, production in kilograms and value in pesos of these leading fruit trees as of 1960 are as follows:

Fruit trees and other cultivated fruits	Number of bearing trees or hills	Total number of trees or hills	Production kg.	Value
Banana		1,107,767 hills	8,343,545	₱715,758
Pineapple	1,267,386 hills	1,538,894 hills	3,577,536	433,239
Mango	4,695 trees	16,198 trees	410,197	148,411
Papaya	59,135 trees	101,995 trees	943,781	90,953
Orange	4,626 trees	15,791 trees	134,790	47,177
Starapple	6,863 trees	32,696 trees	198,719	47,091
Avocado	4,265 trees	19,552 trees	174,469	35,056
Mandarin	2,016 trees	10,214 trees	71,228	32,053
Jackfruit (Langka)	2,785 trees	7,037 trees	178,967	17,897

Vegetables.—The important vegetables commercially grown are eggplant, tomato, ampalaya, green corn, garlic, *kangkong*, onion and squash. In 1960 the area planted to these vegetables was 431.9 hectares with a total produce of 1,187,878 kilograms valued at 210,429 pesos.

Root crops.—The important root crops grown in the province are camote (sweet potato), cassava, tugue, and gabi. The hectarage, production in kilograms, and value in pesos according to the 1960 census figures are as follows:

Crop	Area–hectares	Production kg.	Value
Camote	264.4	1,059,748	P110,174
Cassava	254.5	798,409	71,857
Gabi	25.0	45,382	6,807
Tugue	4.5	79,889	1,341

Camote is the leading root crop and this is grown mostly in Echague. Cultivation of this crop is done mainly on the friable, loose, and alluvial soils along the Cagayan River.

LIVESTOCK AND POULTRY INDUSTRY

Isabela is just as progressive in livestock and poultry production as in farm crops. Isabela is one of the leading provinces in cattle raising. The wide range of grasslands in the province offers opportunity for cattle raising. Also, the big production of corn makes Isabela lead other provinces in both poultry and hog raising.

Based on the 1960 census figures, the total values of livestock and poultry production were 40,160,596 and 1,392,688 pesos, respectively. The number of households reporting, number and value in pesos of livestock and poultry in Isabela are as follows:

Livestock and poultry	Households reporting	Number	Value
Carabao	55,661	117,629	P27,335,373
Cattle	4,809	17,782	3,687,894
Hogs	52,830	163,692	8,248,359
Horses	3,357	5,870	788,908
Goats	1,883	6,341	97,765
Sheep	70	167	2,297
Chicken	58,231	889,315	1,295,825
Ducks	6,427	34,481	53,756
Geese	511	2 352	11,791
Turkeys	238	2,457	21,527
Pigeons	255	9,840	9,789

FARM TENURE

Farm tenure refers to the manner in which a farm is held by its operator. In farm tenure classification, the Bureau of the Census and Statistics during the 1960 census year classified farm operators into five categories; namely (1) full

owners, (2) part owners, (3) tenants, (4) farm managers, and (5) farm operators under other conditions. Tenants are further classified as (*a*) cash tenants, (*b*) fixed-amount-of-produce tenants, (*c*) share-of-produce tenants, (*d*) cash and fixed-amount-of-produce tenants, (*e*) cash and share-of-produce tenants, and (*f*) rent-free tenants.

The total number of farms and the total area of these farms by tenure of farm operator in Isabela according to census figures of 1960 are as follows:

Tenure of farm operator	Total number of farms	Total area of farms–hectares
Full owner	23,110	99 547.7
Part owner	9,310	38,688.9
Tenant:		
Cash tenant	205	1,436.6
Fixed-amount-of-produce tenant	791	2,246.6
Share-of-produce tenant	21,406	53,053.0
Cash and fixed-amount-of-produce tenant	6	12.9
Cash and share-of-produce tenant	314	1,028.4
Rent-free tenant	455	679.5
Other tenants	495	1,954.6
Manager	100	11,741.4
Other forms of tenure	564	3,897.9
Total	56,755	213,487.5

TYPES OF FARMS

The Bureau of the Census and Statistics during the 1960 census year classified farms into 14 types, 10 of which are grouped as crop farms. The 10 crop farms classified based on the first 10 major crops of the country are as follows: (1) palay farm, (2) corn farm, (3) sugar cane farm, (4) abaca farm, (5) tobacco farm, (6) vegetable farm, (7) root crop farm, (8) coconut farm, (9) fruit farm, and (10) coffee farm. The relationship between the physical area planted to a particular crop, on one hand, and the cultivated land in the farm, on the other, is taken into primary consideration. A crop farm is typed according to the particular crop which occupies 50 per cent or more of the cultivated part of the farm.

The four other types of farms are: (11) hog farms with 20 or more hogs regardless of area; (12) livestock farms which satisfy any of these conditions, namely: (*a*) the area is 10 hectares or more with at least 10 heads of any specific kind of livestock and the cultivated area is less than 20 per cent of the total area of the farm, or (*b*) the area is less than 10 hectares provided there are more than 20 heads of any specific kind of livestock (except hogs) and the cultivated area of the

farm is less than 20 per cent of the total area of the farm; (13) poultry farms are farms which do not qualify as crop farms and satisfy any of these conditions, namely: (*a*) there are more than 300 chickens regardless of area, (*b*) there are more than 100 laying chickens or ducks regardless of area, or (*c*) there are more than 200 other specific kinds of poultry other than chickens; and (14) other farms which are those that could not be classified under any of the aforementioned thirteen types of farms, grouped as follows: (*a*) farms planted to palay, corn, coconut, abaca, tobacco, and/or sugar cane without any of them occupying 50 per cent or more of the cultivated land, or (*b*) farms planted to other miscellaneous crops such as cotton, cacao, kapok, ramie, bamboo, etc., even if one of them occupied 50 per cent or more of the cultivated land.

The total number of farms and their corresponding areas by type of farm in Isabela according to census figures of 1960 are as follows:

Type of farm	Total number of farms	Total area of farms–hectares
Palay	35,877	147,980.5
Corn	10,755	27,022.1
Sugar cane	6	13.2
Tobacco	6,556	14,610.9
Vegetable	78	218.5
Root crop	646	1,341.6
Coconut	276	447.6
Fruit	278	1,134.5
Coffee	25	283.7
Hog	8	202.2
Livestock	8	9,540.6
Poultry	83	262.7
Others	2,018	10,429.4
Total	56,755	213,487.5

The total number of farms and the total area of these farms by size of farm in Isabela according to census figures of 1960 are as follows:

Size of farm–hectares	Total number of farms	Total area of farms–hectares
Under 0.5	469	126.2
From 0.5 to under 1.0	1,945	1,147.8
From 1.0 to under 5.0	43,040	100,082.8
From 5.0 to under 10.0	8,557	55,327.4
From 10.0 to under 20.0	2,252	26,309.3
From 20.0 and over	492	30,494.0
Total	56,755	213,487.5

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of (1) the determination of the morphological characteristics of soils, (2) the grouping and classification of soils into units according to their characteristics, (3) their delineation on maps, and (4) the description of their characteristics in relation to agriculture and other activities of man.

The soils, their landscapes and underlying formation are examined in as many sites as possible. Borings with the soil auger are made, test pits are dug, and exposures, such as road and railroad cuts are studied. An excavation or road cut exposes a series of layers collectively called the soil profile. These horizons as well as the parent material beneath are studied in detail and the color, structure, porosity, consistency, texture, and the presence of organic matter, roots, gravel and stones are noted. The reaction of the soil and its available plant nutrients are determined in the laboratory. The drainage, both external and internal, and other features such as the relief of the land, climate, natural and cultural features are taken into consideration, and the inter-relationship of the soil and the vegetation and other environmental features are studied.

On the bases of both external and internal characteristics, the 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 small-scale 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 and great forest areas whose classification 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 have the same parent material. It comprises soils having essentially the same general color, structure, consistency, range of relief, natural drainage condition, and other internal and external characteristics. In the establishment of a series, a geographic name is selected, taken usually from the locality where the soil was first identified. For example, the Ilagan

series was first found and classified in the municipality of Ilagan, province of Isabela.

A soil series has one or more soil types, defined according to the texture of the surface soil. The textural class name such as sand, loamy sand, and sandy loam, etc., is added to the series name to give the complete name of the soil. For example, Ilagan sandy loam is a soil type within the Ilagan 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 mapping unit. Because of its certain specific characteristics it is usually the unit to which agronomic data are definitely related.

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

A soil complex is a soil association composed of such intimate mixture of series, types, or phases that cannot be indicated separately on a small-scale map. This is mapped as a unit and is called a soil complex. If there are several series in an area, such as Cauayan, Ilagan, and San Juan that are mixed together, the complex must bear the names of the two dominant series, as the case may be. If there is only one dominant constituent, the complex bears the name of that series as San Juan or Cauayan complex.

Surface soil and subsoil samples for chemical and physical analyses are collected from each soil type or phase, the number being determined by the importance and extent of such soil type or phase. Soil profiles of important soil types are obtained for morphological studies.

The soil survey party, composed of two or three soils men, maps the area and delineates the various soil types, phases, complexes and miscellaneous land types.

All natural and cultural features found in the area, such as trails, roads, railroads, bridges, telegraph and telephone lines;

barrios, towns, and cities; rivers and lakes; prominent mountains and others, are indicated on the soil map.

THE SOILS OF ISABELA

Soil is a collection of natural bodies which covers the earth's surface, containing living matter, and is capable of supporting plants. When rocks crumble, mainly through temperature changes, the different-sized particles are subjected to further physical and chemical weathering; with the integrated effect of climate, living organisms, parent materials, relief, and time, soil is eventually formed. Since soil is a product arising from the integrated effect of various factors, different kinds of soils are evolved considering the variability of each factor concerned and thus the multitudinous cumulative effects derived therefrom.

Changes within a soil body occur and is, therefore, dynamic in nature. However, changes take place rather slowly and a time may come when such changes stop altogether. At such an instance the soil is said to be in equilibrium and so the soil is called a normal or matured soil.

Soils are developed under two general classifications; namely, (1) soils developed in place or the so-called primary soils, and (2) transported soils or the so-called secondary soils. The primary soils are generally those with rolling to hilly and mountainous relief while transported soils or secondary have level to nearly level relief. Under this classification, the soils of Isabela can be conveniently grouped according to relief and drainage as follows:

I. Soils of the plains:

A. Good drainage:
1. Quingua sandy loam
2. Quingua silty clay loam
3. San Manuel loam
4. San Manuel sandy loam

B. Poor drainage:
1. Bago clay loam
2. Bago sandy clay loam
3. Bago sandy loam
4. Bantog clay loam
5. Bigaa clay
6. Sta. Rita clay loam

II. Soils of the rolling uplands:

1. Alaminos clay loam
2. Cauayan clay
3. Cauayan clay loam
4. Cauayan loam
5. Cauayan sandy loam
6. Guimbalaon clay loam
7. Ilagan loam
8. Rugao clay
9. Rugao clay loam
10. Rugao sandy clay loam
11. San Juan loam

III. Miscellaneous land types:

1. Mt. soils, undifferentiated
2. Hydrosol
3. Beach sand

Soils of the Plains

The flood plains bordering the Cagayan River and its tributaries are the principal areas occupied by soil types under this classification. The soils are very productive but because of their geographical location they are subjected to yearly floods. In some instances the periodic floods of the Cagayan River have augmented the fertility of the alluvial soils although there were cases when coarse sand instead of silt and clay were deposited on the fields which is detrimental.

These alluvial soils are the most extensively cultivated soils of Isabela. In general soils of the plains with good drainage are planted to corn, tobacco, peanut, root crops and vegetables; those with poor drainage are used for lowland rice, tobacco and corn.

QUINQUA SERIES

The relief of the Quingua series is level to nearly level. This series, unlike the San Manuel series with an excellent drainage and to which it is closely similar, is only fairly drained. Soils of this series were formed from recent alluvial deposits. They can be used for many purposes such as lowland rice and for crops requiring good drainage like corn, tobacco, sugar cane, peanut, mongo, and various kinds of vegetables.

The typical profile characteristics of this soil series are as follows:

Depth cm.	Characteristics
0- 30	Surface soil, brown (7.5YR 5/4) silt loam, loam to fine sandy loam; friable and loose; fine granular structure. There are no coarse fragments in this layer.
30- 90	Subsoil, dark brown (7.5YR 4/4) silty clay loam to clay loam; friable and slightly compact; coarse granular; no coarse fragments present.
90-150	Substratum, light yellowish brown (2.5Y 6/4) to dark brown silt loam to silty clay loam; slightly compact, soft when wet; coarse granular structure; no coarse fragments present.

Quingua sandy loam (412).—This soil type occurs in strips along the Pinacauan River between the municipality of Palanan and the barrio of Dibunca in eastern Isabela. It has an area of about 1,141.9 hectares. The crops commonly planted on this soil type are corn, tobacco, peanut, mongo, and vegetables. The sandy loam surface soil is light brown, very friable and loose, and of fine granular structure. Its depth is about 30 centimeters. The subsoil and substratum are more or less similar to the corresponding layers of the series described above.

Quingua silty clay loam (285).—This soil type is found along the course of the Cagayan River between Cauayan and Malagie and in the municipality of Reina Mercedes. It is also found along the courses of the Mallig and the Magat Rivers. It has an aggregate area of about 17,608.3 hectares. The land is flat or nearly so and has fair drainage. Whenever floods occur stream bank erosion results. Floods also leave deposits of coarse sand on the areas mentioned which could eventually cause a change in the texture of the surface soil. As a matter of fact, the places mapped under this soil type have areas with surface soils ranging from fine sandy loam to loam. As formerly stated this variation is mostly due to annual inundation and siltation.

Quingua silty clay loam is yellowish brown to light brown. It is deep, fairly friable and has good drainage.

This soil can be used for many crops. The principal crop grown in the province is corn which is planted almost throughout the year. Due to the continuous cropping of corn, the fertility level of the soil is now very low. Green manuring

to increase its organic matter content is necessary. Areas bordering the river should have some protection against annual floods. Grasses, even only *talahib and tabonok,* and possibly trees like *Ipil-ipil* should be planted closely. If the banks are steep a slight slope should be cut to make planting feasible. Whenever floods occur and the vegetative cover or parts of it are washed away immediate re-planting should be instituted to give the new plants enough time to grow and develop into a thick cover.

SAN MANUEL SERIES

San Manuel soils have level relief. They have good internal drainage. Soils of this series are found along the courses of rivers and the parent material consists of alluvium or soil materials deposited by water. The soils formed from such materials are usually fertile. San Manuel soils respond favorably to soil conservation practices. The series is free from coarse materials like stones and gravels, either on the surface or within the profile.

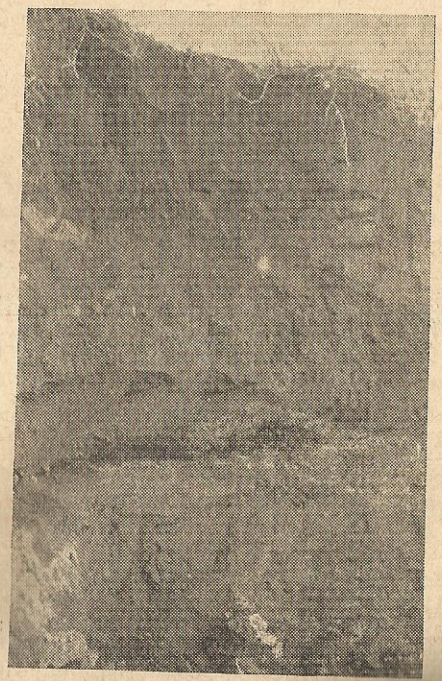

Figure 20. A profile of San Manuel series found along the Cagayan River. This soil is well drained, deep and fairly productive.

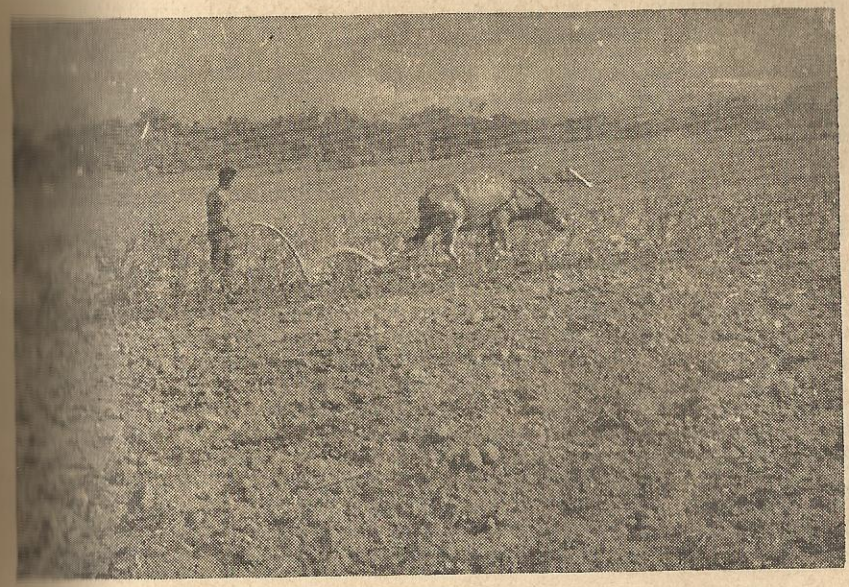

Figure 21. San Manuel soils have flat relief, good granular structure and are very friable. They can be cultivated, any time and are good for crops which require good drainage.

The characteristics of the profile of the San Manuel series are as follows:

Depth cm.	Characteristics
0– 30	Surface soil, grayish brown to pale brown (10YR 5/2) when dry and dark brown (10YR 2/2) when wet; sandy to loamy texture; friable and loose. There are no coarse fragments in this layer.
30– 90	Subsoil, brownish gray to light brown (10YR 6/4) silt loam; friable and loose; fine granular, no coarse fragments. Boundary with surface soil is smooth and diffuse.
90–150	Substratum, yellowish brown to light brown (10YR 5/4) when dry, but becomes a little darker (10YR 4/4) when wet; fine sandy loam; no coarse fragments. Boundary with subsoil is smooth and diffuse.

San Manuel sandy loam (96).—San Manuel sandy loam is found mostly along the Cagayan River and also along the Ilagan River. It exists as narrow flood plains on both sides of the aforesaid rivers. This soil type, because of its location, is subject to inundation when rivers overflow their banks. Floods are frequent between September and December and due

to the recurrence of floods, deposition of soil materials on the plains is inevitable. Consequently, several places subject to flooding have sandy topsoil. Stream bank erosion is also a problem in these areas especially along the inner curves of the river. Portions of land bordering the Cagayan River are usually washed away by floods annually.

San Manuel sandy loam has an aggregate area of about 41,047.3 hectares. It is extensively grown to corn, tobacco, peanut, and vegetables. However, the production is very low and one main cause is the continuous cropping of the soil without benefit of sound management practices. Corn yields from 10 to 15 cavans of shelled corn per hectare, but where proper fertilization is observed the yield is as high as 60 cavans. Native tobacco with the usual yield of 600 kilos per hectare may be made to give as much as 2,000 kilos through the application of 150 kilos of ammonium sulfate, 300 kilos of superphosphate, and 200 kilos of sulfate of potash.

The organic matter content of the soil is low and, therefore, green manuring is highly recommended. In this connection, the planting of mongo or other legumes must be observed and later on when in the succulent stage the crop is plowed under. Since this soil type borders big rivers, and stream bank erosion has always been a hazard, it is advisable to plant grasses or *ipil-ipil* along the river banks to protect the land from further erosion.

San Manuel loam (190).—San Manuel loam covers but a relatively small area compared to the sandy loam type. The loam type has a total area of about 7,812 hectares. This soil type is found in the northern part of the province along the highway connecting Divisoria, Sta. Maria and Sto. Tomas. In the central part of the province it is found in Lullutan near Ilagan and in between Gamu and Naguilian. In southern Isabela a small patch is found in San Agustin.

The characteristics of the loam type are quite similar to those of the sandy loam type. However, the former has a much finer texture and thus many of its physical properties are relatively more intense than those of the latter. For instance, the water holding capacity of San Manuel loam is greater; it can hold water weighing more than half of its own weight. In other words, San Manuel loam is not as droughty as San Manuel sandy loam.

The principal crops grown on this soil type are corn, tobacco, and legumes. Some areas are planted to lowland rice. Corn

yield ranges from 15 to 20 cavans of shelled corn per hectare; it is grown almost the whole year round.

Green manuring to increase the organic matter content of this soil type is necessary. A soil high in organic matter responds better to fertilization than one which contains a very low amount.

BAGO SERIES

Soils of the Bago series are also alluvial soils though some of the soil types have rolling relief. Bago clay, however, has a flat relief which contributes to its very poor external and internal drainage. On the other hand, the sandy clay type, which is a common textural class of this series, often has an undulating to rolling relief that somehow facilitates its external drainage. One characteristic of the Bago series is the abundance of iron concretions on its surface. Originally these iron concretions were within the subsoil but the constant stirring of the soil through tillage operations has brought about their coming to the surface. These concretions are dark brown, almost rounded, smooth, and about three to five millimeters in diameter. There are no other coarse fragments present, but in some places these iron concretions coalesce into larger pieces of about the size of big stones which take the form or appearance of rocks.

Another characteristic of the Bago series is the presence of a very dense, compact and grayish brown layer in the substratum. This layer further impedes internal drainage.

The profile characteristics of the Bago series are as follows:

Depth cm.	Characteristics
0- 25	Surface soil, reddish gray (5YR 5/2) when wet, grayish brown (2.5Y 5/2) when dry; clay, sandy clay to sandy loam; plastic when wet, hard when dry; fine to very fine angular blocky structure. Some iron concretions are found on the surface.
25- 90	Subsoil, reddish gray (5YR 5/2) when wet, gray (2.5Y 5/0) when dry; clay; columnar structure and becomes massive when wet; rounded concretions of about 3-5 mm. in diameter present in this layer; poor in organic matter. The boundary with the surface layer is irregular and slightly diffuse.
90-150	Substratum, light brown to yellowish brown or grayish brown (2.5Y 5/2) clay; contains dark brown mottlings; very plastic and sticky when wet; massive when wet but shrinks into large columnar structure upon drying.

Bago sandy loam (548).—This soil type is found east of Tumauini, west of Gamu, in the barrios of Rizal and San Juan within the municipality of Alicia, and along both sides of the road connecting Santiago and Sinamat, San Mateo. The relief is nearly level to undulating. The surface soil is very friable althóugh it has a slight degree of stickiness due to its being mixed with parts of the clayey subsoil through deep plowing. In spite of the loose and sandy nature of the surface layer, this soil type is nevertheless used for lowland rice culture. This is feasible because water can be held in the soil due to the impermeable and dense clay subsoil and substratum. The yield of rice is, however, very low. The Wagwag variety has a yield of only 15 cavans of palay per hectare. Other varieties planted are Raminad which yields about 30 cavans of palay per hectare and Intan which yields about 35 cavans per hectare. The rice crop is rainfed. Planting is done during August and September while harvesting is in December and January. One crop of rice is grown in the province on this soil type.

The organic matter content of this soil type should be increased as a basic measure to improve rice production. Irrigation by gravity system poses some problems because of the relatively higher elevation of this soil type than those of the other soil types which surround it. However, in the absence of irrigation a second crop of mongo, soybean and the like could be cultivated.

Bago sandy loam covers an aggregate area of about 8,653.4 hectares.

Bago clay loam (410).—This soil type is found in several relatively small areas throughout the province. Some areas have actually coarser texture like loam but were included under the clay loam type. The places where Bago clay loam were delineated in Isabela are between Mallig and Roxas, between Roxas and Gamu, west of Aurora, west of Naguilian, between Cauayan and Alicia, and midway between Echague and Jones. The aggregate area covered by this type is about 14,543.2 hectares.

The relief is almost level which contributes to its poor external draniage. The permeability of the soil is very slow due to the presence of clayey layers in the profile. During the dry season the soil becomes very hard which is almost

impossible to plow. With an adequate irrigation system softening the soil by the application of water during the dry season can be effected for tillage operation. By all means, the soil's organic matter should be increased not only for fertility but for tilth as well. Unburned rice hull, which are quite abundant in the province, are good materials for mixing with the soil to make it friable.

Bago clay loam is mostly used for lowland rice but the yield is very low. It ranges from 15 to 25 cavans of palay per hectare. When the moisture condition of the soil warrants, corn is grown after rice. Inasmuch as corn planting is already within the dry season the yield varies directly with the amount of moisture in the soil. Under the most favorable moisture condition corn yield is about 15 to 20 cavans of shelled corn per hectare.

Bago sandy clay loam (262).—Bago sandy clay loam covers an extensive area in the province. Within the boundaries of this soil type, however, other textural classes of the same series were found such as clay loam, silty clay to very fine clay. The aggregate area classified under this soil type is about 46,636.6 hectares. The largest single area spreads over parts of the municipalities of Santiago, Cordon, Echague, Alicia, Angadanan, San Mateo, Luna, and Cauayan. The rest of this soil type are found in Gamu, Mallig, Roxas, Ilagan, and Tumauini.

The relief is flat and drainage is very poor. This soil type is used mainly for lowland rice. The soil is sticky, soft and plastic when wet; it cracks and is very hard when dry. The dried soil is almost impossible to plow. The subsoil as well as the substratum is very sticky clay. This soil type, as others of the same series, has a very slow permeability. Iron concretions are abundant in the subsoil and substratum. Deep plowing usually brings some of the concretions to the surface.

With rainfall being the only source of water, Bago sandy clay loam when grown to lowland rice yields only from 15 to 20 cavans of palay per hectare. Unless an irrigation system is installed a second crop of rice is not possible. Even peanut, corn or tobacco is difficult to cultivate as a second crop not only because of the lack of moisture but also because of the difficulty of plowing. The heavy application of organic

matter would make the soil somewhat friable, promote granulation, and increase its moisture retentivity.

BANTOG SERIES

Bantog soils were developed from recent alluvial deposits. The relief of this series is level to nearly level. It is poorly drained internally and externally due not only to its level to nearly level relief but also because of the slightly compact and fine textured subsoil and substratum.

The characteristics of the profile of the Bantog series are as follows:

Depth cm.	Characteristics
0– 25	Surface soil, grayish brown (2.5Y 5/2) to brown (10YR 5/3) clay to clay loam; plastic and sticky when wet, hard when dry; no coarse fragments; fair in organic matter.
25– 50	Subsoil, lighter in color than the surface layer, clay; soft and plastic when wet, hard when dry; no coarse fragments; mottlings of bright yellowish brown present.
50–150	Substratum, light grayish brown (2.5Y 5/2) clay; very sticky and plastic when wet; slightly compact.

Bantog clay loam (16).—Bantog clay loam is devoted primarily to rice but a second crop or rotation crop of corn is sometimes planted. Lowland rice, rainfed, yields from 20 to 30 cavans of palay per hectare. With irrigation, the yield increases to about 40 to 50 cavans of palay. The most common variety used is Wagwag. Corn yield is quite low, averaging only about 15 cavans of shelled corn per hectare. The poor drainage condition of the soil is one contributing factor to low corn yields.

This soil type needs the addition of organic matter to enrich the soil as well as to improve its physical condition. With proper fertilization, rice and corn yields could be increased by more than a hundred per cent.

Bantog clay loam is found scattered as small separate areas in places such as Baculod, Ilagan; between the muncipalities of Roxas and Mallig; south of the town proper of Reina Mercedes; and in the municipality of Santiago. The aggregate area of this soil type is about 4,747.9 hectares.

BIGAA SERIES

Bigaa series has a level relief. It is poorly drained mainly because of the compact and fine textured subsoil and substratum. The soils of the series harden and crack during the dry season. For this reason it is very difficult to work the soil during summer. However, tillage is possible in places where irrigation water is available to moisten the soil. Rock outcrops or coarse fragments are not found on the surface or within the profile. The poor drainage and the fine textured soils of this series make it primarily suitable for lowland rice culture.

Bigaa clay (192).—Bigaa clay is found between the barrios of Manaring and San Juan, municipality of Ilagan; between the towns of Mallig and Roxas; north of the town proper of Gamu; in the municipality of Aurora; and between the towns of Cordon and Santiago. The total area covered by this soil type is about 29,087.4 hectares. Bigaa clay is almost level and is poorly drained internally and externally. It has a profile consisting mostly of dense clay and the soil is rather deep. However, due to poor drainage and the clayey texture very limited kinds of crops can be grown.

The profile characteristics of this series as represented by Bigaa clay are as follows:

Depth cm.	Characteristic
0– 20	Surface soil; dark gray (2.5Y 4/0) when moist, light gray when dry; layer with streaks of red; clay; plastic and sticky when wet, hard when dry; coarse granular to prismatic in structure. No coarse skeletons present.
15– 50	Subsoil, very dark gray (2.5Y 3/0) with dark brown mottlings; clay; very plastic and sticky when wet, hardens and cracks upon drying; has prismatic macro structure. Non-calcareous.
50–150	Substratum, dark gray (5Y 4/1) with olive brown mottlings; clay; very sticky and plastic; massive structure. No coarse fragments and non-calcareous.

A large part of this soil type in the municipalities of Roxas and Aurora is presently artificially irrigated by the Siffu River Irrigation System. This system is capable of irrigating about 18,000 hectares. Rice is the principal crop which yields from 20 to 30 cavans of palay per hectare. Rice is usually planted in September and harvested in February. The varieties used are Wagwag and Raminad which are late maturing.

The friability of this soil type could be improved through the addition of organic matter either by means of green manuring or the incorporation of animal manure into the soil. Fertilization is also necessary. With the correct kinds and proportions fertilizer application may increase the present yield up to 100 cavans of palay per hectare.

With the adequate irrigation of this soil type, rice production could be boosted considerably. Even if water were available after the first crop, a second crop of rice is not advisable. Instead a legume crop, preferably mongo, soybean, or peanut, should be planted. There will be some difficulty at the start due to the inherent plasticity and stickiness of the soil but if organic matter were incorporated, as recommended, the soil gradually becomes friable so the tillage problem would be eliminated.

STA. RITA SERIES

Sta. Rita series has flat relief and drainage that is both poor internally and externally. The series belongs to a group of soils with fine texture and of recent alluvial deposition. It is characterized by a black surface soil underlain by a brownish subsoil. The textures of all the layers are of very fine clay. There are no concretions or coarse fragments either on the surface or in any of the layers within the profile.

Sta. Rita soils are extensively used for lowland rice culture. Rice is oftentimes rotated with corn or peanut. Being deep and usually high in calcium, these soils are generally productive.

Sta. Rita clay loam (119).—This soil type is found in the municipalities of San Mateo, Cabatuan, and Luna. It covers an area of about 14,723.5 hectares. Sta. Rita clay loam is flat or nearly so with a very low grade of slope.

The profile characteristics of this soil type are as follows:

Depth cm.	Characteristics
0– 20	Surface soil, dark gray to almost black (5YR 3/1) clay; plastic and sticky when wet, hard when dry but does not crack nor shrink much. Fairly rich in organic matter.
20– 70	Subsoil, black to dark brown to reddish brown (5YR 4/4) clay; plastic and sticky when wet, hard when dry; moderately coarse granular in structure; no coarse fragments. This layer grades very gradually with the overlying layer.
70–150	Substratum, yellowish brown clay; very plastic and sticky; structureless to very fine granular; no coarse fragments.

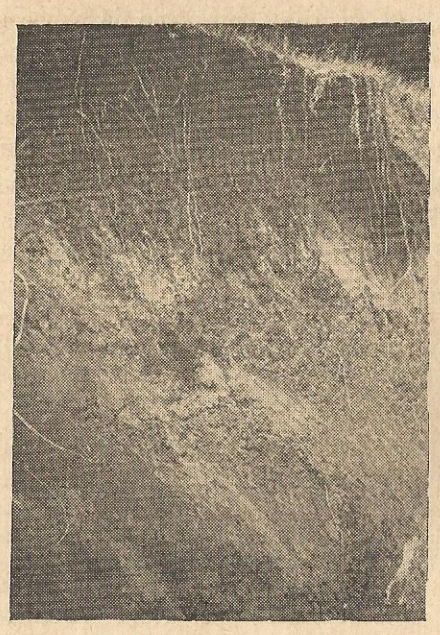

Figure 22. A profile of Sta. Rita series found in Cabatuan. It has dense soil layers, a profile characteristic good for lowland rice culture.

Figure 23. Landscape of Sta. Rita soil showing generally flat relief. This soil has a very slow permeability. Some paddies in the foreground are newly planted to lowland rice.

The permeability of this soil type is very slow and it is very commonly used for lowland rice. Wagwag rice variety yields about 55 cavans of palay per hectare, but when fertilized the production is increased up to 80 cavans of palay. Rice is planted in August and harvested from December to January. Corn is planted after rice which is usually done in May and harvested after three months. The yield of corn is from 15 to 25 cavans of shelled corn per hectare.

In places where irrigation is available, those served by the Magat River Irrigation System, the average rice yield is 70 cavans of palay per hectare when fertilization is observed. Corn cultivation has also been enchanced. Formerly, farmers had to depend on rainfall which comes in May before they could prepare their fields for planting. Tobacco is also planted on this soil type but to a limited extent. Mongo is cultivated too and the yield is fairly high.

Irrigation has tremendously increased crop production on this soil type. Furthermore, the assured water supply has eliminated the uncertainties of field preparation for the different crops. Crop production would further be increased with judicious fertilizer and lime application as well as the addition of organic matter.

Soils of the Rolling Uplands

There are eleven soil types classified under the general classification of soils of the rolling uplands in Isabela. Some of these soil types are suitable for cultivation and some are suitable only for pasture purposes or for woodland. Of the pasture areas presently being operated most of them have already been badly eroded mainly due to excessive grazing. Crop production on the cultivated areas is low. Low production is attributed to factors such as low fertility of the soil which in the first place is inherently low, continuous farming without fertilization, and soil erosion.

The different soil series found in the rolling uplands are Alaminos, Cauayan, Guimbalaon, Ilagan, Rugao, and San Juan series.

ALAMINOS SERIES

Soils of the Alaminos series are residual soils derived from the weathering of basalts and andesites. The relief is rolling to hilly with some level areas. Drainage is good to excessive.

The hilly areas are covered with primary and secondary forests while the rolling and level areas are mostly under the *parang* type of vegetation. Some of the level areas are cultivated to rice, corn, and coconut.

Alaminos clay loam (407).—This soil type is found around the town of Palanan and extends toward Palanan Bay. It has an approximate area of 6,911 hectares. The profile characteristics of the Alaminos series as typified by the clay loam type are as follows:

Depth cm.	Characteristics
0– 25	Surface soil, light brown to pale reddish brown (2.5YR 4/4) clay loam; loose and friable; slightly sticky when wet, crumbles easily upon drying; granular in structure; high organic matter content; no coarse skeleton.
25– 80	Subsoil, reddish brown (5YR 5/4) clay loam to clay; slightly compact and sticky when wet, friable when moist, loose when dry; columnar structure; roots can easily penetrate this layer.
80–150	Substratum, reddish brown (5YR 5/4) to pale yellowish red clay loam to clay; has similar characteristics as those of the subsoil except the presence of red splotches in the substratum. Stones could be found at a depth of from 3 to 4 meters from the surface.

Lowland rice is planted on small level areas and has a yield of from 15 to 20 cavans of palay per hectare. The rice variety commonly planted is Binuhangin although Elon-elon and Wagwag are sometimes cultivated. Corn yields from 10 to 15 cavans of shelled corn per hectare. The common variety planted is White Flint. Coffee, cacao, and coconut are grown on the cultivated rolling areas.

CAUAYAN SERIES

Cauayan soils are on older terraces and were developed from pre-existing old alluvium mostly originating from sandstone. This is shown by the fact that these soils are found adjacent to and along the strips of recent alluvial soils alongside the Cagayan River. The presence of rounded gravels in the substratum signifies their mode of formation. The rolling relief of the land is attributed to previous and long past erosions. Large portions of the series are grasslands which somehow reflect the low fertility of soils of the series. The external drainage is excessive while internal drainage is poor to fair. Iron concretions are oftentimes found deposited in the lower part of the subsoil.

The typical profile characteristics of the Cauayan series are as follows:

Depth cm.	Characteristics
0– 20	Surface soil, dark brown (7.5YR 4/2) to light brown (7.5YR 6/2) when dry, dark reddish brown (5YR 5/2) when wet; textures are sandy clay loam, loam, clay loam, and even clay. The clay type is sticky and plastic, with great swelling and shrinking capacity.
20– 60	Subsoil, gray to dark reddish gray (5YR 4/2) clay; soft, plastic and sticky when wet, hard when dry; slightly compact; some iron concretions are found in the lower part of this layer.
60–150	Substratum, dark gray (10YR 4/1) to grayish brown clay; plastic when wet, hard when dry; slightly compact and cloddy. Some concretions are also present in this layer.

Cauayan clay (398).—Cauayan clay is found as low-lying areas in the northern part of the province between Tumauini and San Pablo. The land is very slightly undulating with the almost level places more extensive than the undulating portions. This soil type is very poorly drained due to the fine texture of the soil as well as its level topography and the fact that it is found on a large depression in the Cagayan Valley.

The clay surface soil is dark brown and is very sticky and plastic when wet. Swelling and shrinking of the soil occurs alternately in consonance with the weather. During the rainy season the soil is water-logged because of the lack of natural outlets for the accumulated runoff. The lower boundary of the subsoil is 60 centimeters from the surface. The subsoil consists of gray to dark reddish gray clay. The layer underlying the subsoil is also clay which is soft when moist, very sticky and plastic when wet, and dark gray in color.

Rice is the principal crop while corn, tobacco and peanut are the secondary crops. Rice yields about 15 cavans of palay per hectare and corn about 15 cavans of shelled corn.

This soil type covers about 4,627.7 hectares.

Cauayan clay loam (397).—Cauayan clay loam is found in separate places in the province; namely, in Cordon, between the highway from Jones to Echague and the Isabela-Nueva Vizcaya provincial boundary, southeast of Cauayan, and in two separate areas south and southeast of Roxas. The

aggregate area occupied by this soil type is about 21,274.4 hectares. The relief, generally, is undulating.

The brown to dark brown clay loam surface soil is about 15 centimeters deep. It is slightly friable and is granular in structure. Some gravels are mixed with the surface soil. The other layers within the profile have characteristics which are more or less similar to those of the corresponding layers of the series described above.

Some of the crops grown are corn, tobacco, and banana. The uncultivated portions are covered by grass and are utilized for pasture.

Cauayan loam (622).—This soil type is found surrounding the town of Santiago and as a tapering strip from Echague in the south to Alicia and beyond in the north. The total area occupied by this soil type is about 8,473.1 hectares. It is also undulating in relief with the external drainage very excessive while its internal drainage is but poor to fair.

The loam surface soil is about 15 centimeters deep. It is brown to dark brown, friable, and some gravels are mixed in it. The subsoil is clay, grayish brown to gray with some red mottlings. Its lower depth is 30 to 40 centimeters from the surface. The substratum is also clay and is dark reddish brown. Manganese concretions are present in this layer.

Corn, tobacco, banana, and some vegetables are the principal crops grown. The yields of these crops are below standard. Big portions of this soil type are urban areas.

Cauayan sandy loam (396).—Cauayan sandy loam is found in separate places in the province. The biggest area extends from the most southern tip of Isabela towards the north covering practically the eastern sections of the towns of San Agustin, Jones, Echague, and Angadanan. The other places where it is found are Cauayan, San Mateo, Cabatuan, Reina Mercedes, Roxas, Gamu, and Ilagan. The total area covered is about 87,865.2 hectares. The land is undulating to slightly rolling. External drainage is excessive while internal drainage is poor.

The surface soil is dark gray to grayish brown sandy loam to sandy clay loam. There are plenty of iron concretions on the surface. In some instances, pieces of coalesced iron concretions appear as rock outcrops. These hamper plowing and cultivation.

A very large area is covered with native grass which is utilized for pasture. The cultivated areas are devoted to lowland rice, corn, and tobacco. Raminad Strain III yields about 40 to 60 cavans of palay per hectare under favorable conditions. Otherwise a yield of 10 to 15 cavans of palay per hectare is usually realized. Rice is planted between July and August and harvested in December. Corn is planted in June and harvested in August.

Cauayan sandy loam needs fertilization and the application of lime. Soil exhaustion is very evident in many corn fields. For fertilizers to be more effective, the organic matter content of the soil should be increased. This could be achieved through green manuring. The organic matter in the soil will also make it friable.

Land intended for pasture should be cultivated to better kinds of grasses or legumes. At present areas used for pasture are covered by inferior grasses such as *cogon, amor-seco,* and *talahib.* For pasture grasses to thrive well the application of lime and fertilizer is also important.

GUIMBALAON SERIES

Soils of the Guimbalaon series are of primary origin developed from igneous rocks like andesites. Guimbalaon series is rolling to hilly. External drainage is excessive; internal drainage is fair to good. The series is characterized by brown soils with some outcrops of basalt and andesite rocks.

A typical profile of the series is characterized as follows:

Depth cm.	Characteristics
0– 25	Surface soil, brown to dark brown; loam, clay loam to clay; slightly sticky when wet, friable when moist; fair in organic matter. Some concretions, gravels and boulders present on the surface.
25– 70	Subsoil, reddish brown clay; slightly sticky when wet, friable when moist; good medium granular structure; some coarse fragments present.
70–150	Substratum, clay; brownish red weathered materials of igneous rock origin present. Boulders in some places are plentiful.

Guimbalaon clay loam (280).—Guimbalaon clay loam is found in the southern part of the province specifically in the municipalities of Jones and San Agustin and it covers a total area of about 8,052.4 hectares. The land is rolling to hilly.

A great part is still under thick forest, but places along roads are already cleared and planted to such crops as corn, upland rice, and fruit trees. In the cultivated areas erosion is a problem which should be controlled or minimized so as not to jeopardize the still deep soil.

The soil is fairly rich in organic matter as most of the land under cultivation was recently opened. The deep soil is friable when moist and slightly sticky when wet. Some boulders as outcrops are present which to a certain extent hamper cultivation.

Corn yields about 20 cavans of shelled corn per hectare. The yield can be considerably increased by proper fertilization. Coffee is extensively planted on the hillside and because of the favorable elevation the trees thrive well. Bananas are also grown considerably.

ILAGAN SERIES

The rolling to hilly land around Ilagan was classified under the Ilagan series. The external drainage is excessive and with the absence of thick vegetative cover necessary for soil protection, erosion tends to be very severe. The compact nature of the substratum also prevents the rapid infiltration of water so that during heavy rains most of the water becomes runoff while only an insignificant volume is absorbed. The parent rock of the Ilagan series is soft sandstone which is poorly stratified.

A large part of the area covered by this series is covered by grasses of various kinds. Raising of cattle has been initially successful but because of heavy grazing, soil erosion and consequently low soil fertility resulted. The places which are relatively flat and cultivated are also subject to erosion.

The profile characteristics of the Ilagan series are as follows:

Depth cm.	Characteristics
0– 20	Surface soil, dark brown (7.5YR 5/6) when dry, yellowish brown (10YR 3/3) when wet; sandy clay loam, sandy loam to loam; hard to slightly compact when dry but becomes soft when wet, coarse granular structure; poor in organic matter; no coarse fragments present.

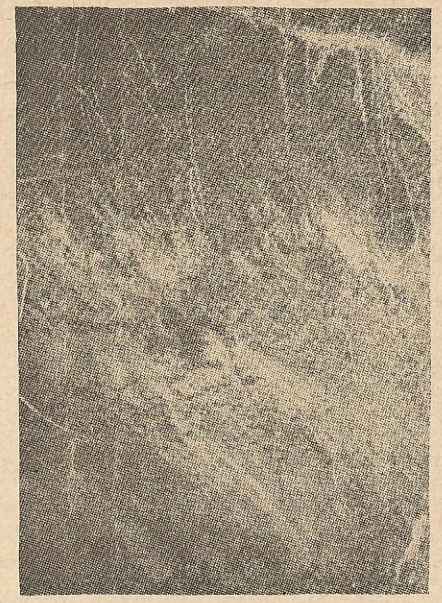

Figure 24. A profile of Ilagan series, Ilagan, Isabela.

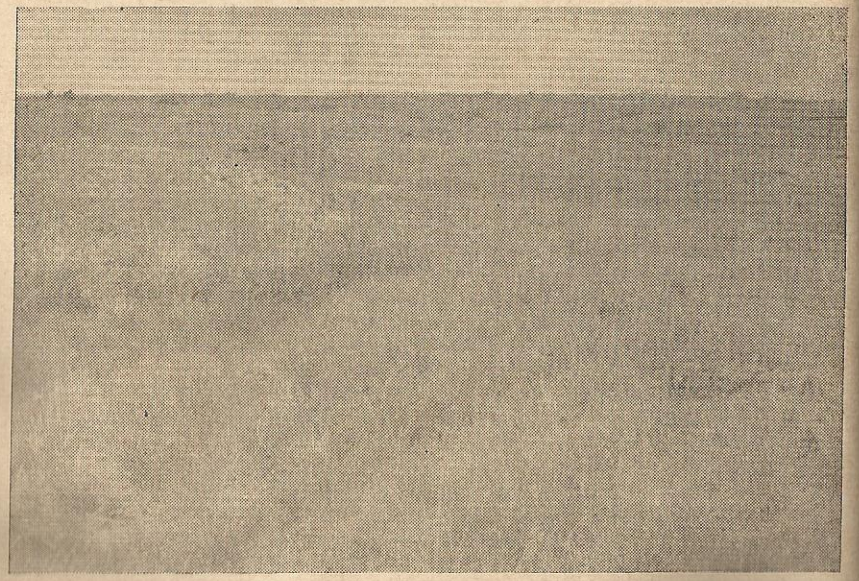

Figure 25. Landscape of Ilagan series covered mostly with grass. This series is rolling to hilly.

30–45 Subsoil, yellowish red (5YR 5/6) when dry, yellowish brown (10YR 5/4) when wet; clay to sandy clay; compact; massive to coarse granular in structure; some red mottlings are present; no coarse fragments.

45–70 Lower subsoil, very pale brown (10YR 7/4) when dry, yellowish brown (10YR 5/4) when wet, some cloudy specks of gray (2.5YR 5/0) are evenly distributed in this layer; clay loam to loam; compact and very hard when dry, soft when wet.

70–150 Substratum, light yellowish brown (10YR 6/4) when dry, yellowish red (5YR 5/8) when wet; soft sandstone (sandy loam) intermixed with some thin layers of shale; very compact and massive; no other coarse fragments present.

Ilagan loam (903).—Ilagan loam is quite extensive. It extends from Ilagan towards the south covering parts of the municipalities of San Mariano, Naguilian, Reina Mercedes, Cauayan, and Angadanan. The total area covered by this soil type is about 118,997 hectares. The land is rolling to hilly and is mostly covered with grass. It is extensively used for pasture purposes. However, because of excessive grazing the grass cover consequently is sparse. With practically no protection at all, sheet and gully erosion become more severe after every heavy rainfall. Likewise the hillsides are characteristically marked by catsteps or benches caused by the trampling of cattle.

Within this soil type are other textural classes brought about by different degrees of erosion as well as deposition of eroded materials. The soil is of medium fertility and it easily responds to simple soil management practices such as green manuring, liming, and fertilizing. In the cultivated areas soil erosion control measures should first be instituted before lime or fertilizer is applied.

Tillage operations are not difficult because the soil is friable especially when with optimum moisture content.

The crops grown are tobacco, corn, and some vegetables. The yield of corn, which depends much on the availability of moisture, ranges from 10 to 15 cavans of shelled corn per hectare. Native tobacco yields only about 460 kilograms per hectare. Bananas, which are also grown in a limited scale, thrive rather poorly.

RUGAO SERIES

Rugao series occurs as rolling lands in the northern part of Isabela running southward along but not bordering the

eastern side of the Cagayan River and terminating at the southeastern part of Ilagan. The rolling relief is, however, broken by several low flat areas that are cultivated to crops. The rolling lands are mostly covered by grasses and sporadic growths of *binayoyo* and guava trees. The series is also found at the southwestern corner of the province near the town of Cordon. The external drainage is excessive whereas the internal drainage is poor to fair. Some manganese concretions are found in the surface layer but below the profile are layers of riverwash stones while in other sections within the profile stones are distributed in the soil mass. This formation is a terrace and represents old alluvium developed in place. The work of erosion has carved the land into its present rolling condition.

The land is not cultivated much and the crops that are grown are corn, banana, kapok, mango, and some vegetables. On the other hand, cattle raising is an important industry in the area.

Rugao series has the following typical profile characteristics:

Depth cm.	Characteristics
0– 20	Surface soil, brown to reddish brown (5YR 4/4) when wet, dark brown when dry; sandy clay loam, sandy loam, clay loam to clay; friable when moist, a little hard and brittle when dry; low in organic matter; some manganese concretions and fine gravels are found in this layer; non-calcareous.
20– 50	Upper subsoil, yellow (10YR 7/6) when dry, dark brown (7.5YR 4/4) when wet; clay loam to clay; hard when dry, slightly friable when moist; medium weak columnar structure. Some fine gravels are found in this layer.
50– 70	Middle subsoil, yellow (10YR 7/6) when dry, dark brown (7.5YR 4/4) when wet; clay to clay loam; coarse gravels of up tc 5 centimeters in diameter are found in this layer, sometimes cobbles of up to 10 centimeters in diameter are intermixed.
70–100	Lower subsoil, yellow (10YR 7/6) when dry, yellowish brown (7.5YR 5/6) when wet; clay to clay loam; coarse granular; some weathered rocks are mixed with gravels and cobbles.
100-150	Substratum, very pale brown (10YR 7/4) when dry, yellowish brown (10YR 5/4) when wet; clay to sandy clay loam; several weathered rocks mixed with riverwash stones are found in this layer. Some stones beneath this layer were water deposited.

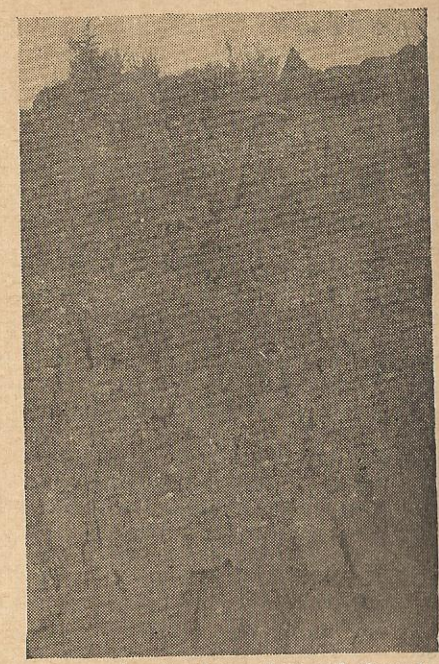

Fig. 26—A profile of Rugao series showing a deep soil characterized by the presence of numerous riverwashed stones imbedded in the profile.

Fig. 27—Landscape of Rugao series. The hilly terrain and severe erosion make cultivation highly speculative. The land needs intensive soil conservation practices.

Rugao sandy clay loam (824).—Rugao sandy clay loam is found east of the Cagayan River starting from the vicinity of Ilagan and extends northward to the Isabela–Cagayan provincial boundary. This soil type is subject to erosion and as a result the depth of the surface soil is only 15 centimeters. The texture ranges from sandy loam to sandy clay loam and the soil is fine granular in structure. Manganese concretions are found in the surfacelayer. The color of the surface soil is reddish brown in some places while in others it is dark brown. Light colored top soil of this soil type indicates that erosion has been going on. In many places, especially along trails and dirt roads, gully erosion is quite severe. The total area covered by this soil type is about 27,044 hectares.

Rugao sandy clay loam has undulating to rolling relief. External drainage is excessive which contributes greatly to soil erosion. Furthermore, the permeability of the soil or the rate at which water goes through a given soil mass is rather slow and, therefore, the volume of runoff is great.

There are no stones or other big rocks on the surface which might interfere with tillage. Almost the whole area of this soil type is open land which is covered by grasses of different kinds and brushes as well as some bamboo, *binayoyo*, and guava trees. The grasses consist chiefly of *amor seco*, *talahib*, and cogon.

Very little farming is being done on this soil type. The permanent crops found in the area are bananas, mango and kapok trees, while the seasonal crop is corn. Corn yield is very low, averaging only about 10 cavans of sheeled corn per hectare. Some areas which may be suitable for farming should only be tilled with soil erosion control measures. Terracing and strip cropping are recommended. A system of crop rotation with green manuring instituted once in four or five years is also necessary.

Rugao clay loam (401).—This soil type is found north and south of San Mariano and also southwest of Cordon adjacent to the Nueva Viscaya-Isabela provincial boundary. There are valleys in between the hills which are fairly level and are

cultivable. A large portion of this soil type cannot be safely cultivated due to soil erosion hazard. Part of the area are open grasslands and other parts are covered by secondary and primary forest. The best uses to this soil type are for pasture for the presently grass-covered areas and for woodland or forest for the steep or forest-covered places.

Where crop cultivition may be possible, erosion control measures should be observed such as terracing, contour and strip cropping, as well as green manuring.

This soil type covers a total area of about 17,247.7 hectares.

Rugao clay (400).—Rugao clay is found also east of the Cagayan River extending from San Pablo northwards to the Isabela-Cagayan provincial boundary. The relief is rolling with some ranges of hills which run in the north-south direction. The area is crossed by several intermittent streams. The intermittent nature of these streams shows the effect of deforestation of the watershed. The land is also broken by several gullies which further attest to the extreme abuse in the use of the land. The land is very susceptible to erosion not only through runoff during heavy rains but also because of its lack of proper vegetative cover.

The area is at present covered by grasses of several species. Sporadic growth of acacia, *binayoyo*, and other non-commercial trees occur on several places in the area. The poor growth of vegetation shows the low fertility of the soil. The dominance of some kind of grass like *amor seco* is a further indication of its degenerated fertility. *Talahib* is predominantly abundant along creeks and ravines as this species of grass requires moist soil.

The soil although classified as clay type is found in some places of the area with a clay loam texture. In general, however, the soil is only slightly friable when moist but becomes hard when dry. Concretions and some fine gravels are present on the surface. There are no big stones. The depth of the surface soil ranges from 10 to 20 centimeters; the soil structure is fine granular. The subsoil is clay loam, fairly deep and has a columnar structure. It is hard and

brittle when dry but becomes soft when wet. The surface soil and subsoil both have high water holding capacity which is about 55 per cent in each case. Fine gravels and smooth riverwashed stones of about 0.5 to 1.0 centimeter in diameter are present below the subsoil. These stones attest to the method of formation of this old plain which is one of the terraces existing along the Cagayan River.

The open grasslands classified under this soil type are best suited for pasture. For maximum benefits improved kinds of pasture grasses such as Alabang X, Guinea grass, and Napier should be planted in place of the native grass. The planting of grasses should also be supplemented by the planting of some legumes like tropical kudzu. In addition, grazing should be controlled.

SAN JUAN SERIES

San Juan series is quite similar to the Rugao series with the exception that the former is very shallow and badly eroded and its substratum is full of riverwashed stones. San Juan soils represent the upper terraces in the valley; they are found adjoining the mountain ranges in the western part of the province. Like the Rugao series the San Juan series is also rolling to hilly. This relief is attributed to soil erosion. The external drainage is excessive while the internal drainage is poor. The parent material of this series is derived from old alluvium. The stones beneath the substratum, consisting mostly of sandstone and a variety of other kinds, also contribute a little to the formation of the soil. The native vegetation consists mostly of native grasses. Some parts are under non-commercial timber. The areas cultivated have already very shallow soils.

San Juan series has profile characteristics as follows:

Depth cm.	Characteristics
0– 15	Surface soil, light gray (5Y 7/1) to gray (5Y/1); sandy clay loam, loam, to clay; slightly friable and loose when moist; fine granular structure.
15– 40	Subsoil, brownish gray (5Y 5/2) to dark grayish brown (2.5Y 5/2); clay; slightly compact, plastic and sticky.
40–150	Substratum, sandy clay mixed with plenty of riverwashed stones ranging in size from 2 to 10 centimeters in diameter. Weathered stones consisting mostly of sandstone are found beneath this layer; very compact.

San Juan loam (874).—A part of this soil type is found in the northwestern part of Isabela. It occurs as a low-lying range of hills bounding the Mallig Plain with excessive external drainage. The land is partly covered by grasses and partly by non-commercial forest. Those under grass are very severely eroded and in many places, the rounded gravels and stones are exposed which make cultivation impracticable or downright impossible. In the wooded area the soil is still thick and is almost black due to organic matter. Consequently the soil in these parts is friable and loose. In this area, the Philippine Oil Development Company drilled for oil but later the holes were sealed due to no indications of oil. The area is suitable only for pasture but cultivation may be done where the soil is still deep provided a system of erosion control shall be established. However, a better use of the land is for orchard.

Another location of this soil type is along the eastern border of the Mountain Province. The relief is also rolling to hilly and the external drainage is also excessive. Soil erosion is severe. The vegetation consists mostly of grass with patches of second growth trees. The soil is shallow with gravels and stones exposed. For this reason it is not recommended for cultivation to annual crops. Instead it is better utilized for pasture, orchard or woodland. When used for orchard the trees should be planted along the contour and a good cover crop of legumes should be planted. When used for pasture, good kinds of grasses should be introduced like Alabang X and interplanted with tropical kudzu. An improved system of pasture land cultivation as well as good pasture management will bring more returns from the land.

The aggregate area covered by this soil type is about 59,257.6 hectares.

MISCELLANEOUS LAND TYPES

Classified under this general heading are areas exhibiting no developed profiles, or because of relief, physical and chemical characteristics of the soil materials, and other adverse characteristics are not suitable for agricultural purposes. There are three miscellaneous land types delineated in Isabela; namely hydrosol, beach sand, and mountain soils, undifferentiated.

Hydrosol (1).—Hydrosol areas are alluvial deposits made along sea coasts especially around mouths of rivers. These areas are either totally under sea water throughout the year or partially under water. Under saline conditions, only a certain type of vegetation grows on the area. Generally, it is covered by mangrove trees such as *bakauan, api-api, langa-rai,* etc. The trees especially *bakauan,* make good firewood. It is a general practice for a municipality to lease mangrove swamps either for fishponds sites or for the propagation of the native trees for firewood supply. In some Asian countries, the trees are totally cut down, the area replanted to the same species with better distancing and through selective cutting or rotation of sections the area assures a steady and dependable source of firewood.

For fishponds, a swamp, with a clay or clay loam bottom, whose water is deep enough and is protected from strong sea waves or current is desired. Furthermore, the water should be brackish and, therefore, places around mouths of rivers are quite suitable sites. When necessary the soil should be fertilized in order that a good growth of algae, the food of milkfish, is produced.

The aggregate area covered by hydrosol is about 781.3 hectares.

Mountain soils, undifferentiated (45).—This miscellaneous land type comprises a large area which is occupied by the Sierra Madre Range in eastern Isabela. This mountain range consists of steep slopes and in general the mountains have high elevations. Some places are about 1,784 meters high. At present the area is covered by thick dipterocarp forest. There are also places of considerable extent which are covered by narra and ipil trees wherein several logging concessions have been granted.

These mountains are mainly of volcanic origin and consists of basaltic and dioritic rocks with gabbros and peridotites as well as other coarse grained basic rocks. In the southeastern section of the province are hills of limestone formation. Soils derived from the volcanic rocks are red and deep which are classed under the so-called latosols. Soils derived from limestones as found in southeastern Isabela are black and shallow.

The total area covered by this miscellaneous land type is about 500,271.4 hectares.

Beach sand (118).—Beach sand is strictly not considered soil as the sand is constantly being stirred and distributed by the sea tides or current and, therefore, no profile development can take place. This miscellaneous land type consists of very loose sand which has a very low water holding capacity. Only certain types of plants would grow on it and these usually are vines of the morning glory family, *pandan,* aroma, and agoho.

For commercial crops, only coconut seems to be adapted to this type of land. Vegetables can be planted provided frequent irrigation is made and plenty of organic matter are added into the vegetable plots.

This miscellaneous land type is found only along the eastern coast of Isabela bordering the Pacific Ocean. The total area covered is about 1,141.9 hectares.

TABLE 3.—*Area and proportionate extent of each soil type or miscellaneous land type and major bodies of water in Isabela.*

Soil or miscellaneous land type number	Soil type or miscellaneous land type	Area (hectares)	Per cent
407	Alaminos clay loam	6,911.00	0.65
410	Bago clay loam	14,543.20	1.36
402	Bago sandy clay loam	46,636.60	4.37
548	Bago sandy loam	8,653.40	0.81
16	Bantog clay loam	4,747.90	0.45
192	Bigaa clay	29,087.40	2.73
398	Cauayan clay	4,627.70	0.43
397	Cauayan clay loam	21,274.40	1.99
622	Cauayan loam	8,473.10	0.79
396	Cauayan sandy loam	87,865.20	8.24
980	Guimbalaon clay loam	8,052.40	0.76
903	Ilagan loam	118,997.00	11.16
412	Quingua sandy loam	1,141.90	0.11
985	Quingua silty clay loam	17,608.30	1.65
400	Rugao clay	5,709.50	0.54
401	Rugao clay loam	17,247.70	1.62
824	Rugao sandy clay loam	27,044.00	2.53
874	San Juan loam	59,257.60	5.56
190	San Manuel loam	7,812.00	0.73
96	San Manuel sandy loam	41,047.30	3.85
119	Santa Rita clay loam	14,723.50	1.38
45	Mountain soils, undifferentiated	500,271.40	46.91
1	Hydrosol	781.30	0.07
118	Beach sand	1,141.90	0.11
	Major bodies of water	12,800.30	1.20
	Total	1,066,456.00	100.00

TABLE 4.—*Key to the soils and miscellaneous land types of Isabela and their respective vegetable covers.*

Soil type, misc. land type number	Soil type or Miscellaneous land type	Parent Material or Parent Rock	General Relief	Drainage: External	Drainage: Internal	Present use/vegetation
16 192 119	Bantog clay loam Bigaa clay Santa Rita clay loam	Recent	Level to nearly level	Poor	Poor	Lowland rice, corn. Lowland rice. Lowland rice, corn, peanut, mongo, tobacco.
412 285	Quingua sandy loam Quingua silty clay loam	alluvial deposits		Fair to good	Fair to good	Rice, corn, diversified crops. Corn, tobacco, legumes, lowland rice.
190 96	San Manuel loam San Manuel sandy loam			Good to excellent	Good to excellent	Corn and diversified crops. Corn, tobacco, peanut, vegetables.
410	Bago clay loam		Nearly level	Poor	Poor	Lowland rice, corn.
262	Bago sandy clay loam		Level	Very poor	Very poor	Lowland rice.
545	Bago sandy loam		Nearly level to undulating	Fair to good	Poor	Lowland rice.
398 397 622 396	Cauayan clay Cauayan clay loam Cauayan loam Cauayan sandy loam	Older alluvial deposits	Undulating to rolling	Excessive	Poor to fair	Lowland rice. Corn, tobacco, banana, vegetables. Lowland rice, corn, tobacco, banana, vegetables. Lowland rice, corn, tobacco; grass.
400 401	Rugao clay Rugao clay loam		Rolling with some level portions			Grass and trees. Grass; forest.
824	Rugao sandy clay loam		Undulating to rolling w/some level portions			Banana, mango, kapok, corn; grass.
674	San Juan loam		Hilly			Grass; forest.
407	Alaminos clay loam	Basalt and andesite	Rolling to hilly with level areas.	Good to excessive	Poor	Rice, corn, coconut, coffee, cacao; grass; forest.
280	Guimbalaon clay loam				Fair to good	Corn, upland rice, banana, coffee, fruit trees; primary forest.
903	Ilagan loam	Sandstone	Rolling to hilly	Excessive	Poor	Tobacco, corn, vegetables; grass.
1	Hydrosol	Alluvial deposits	Level	Very poor	Very poor	Mangrove; fishponds.
118	Beach sand		Nearly level	Excellent	Excellent	Coconut.
45	Mountain soils, undifferentiated		Mountainous			Forest

LAND-USE, SOIL MANAGEMENT AND WATER CONTROL ON THE LAND

Isabela Province has principally an agricultural economy. Land for farming, grazing, and forests are relatively sufficient for the people of the province. However, an antiquated system of tillage operation and *kaingin* cultivation are still practiced by many inhabitants.

Lowland farms add up to almost one-half of the total farm area of the province. However, irrigated farms constitute only a small portion of the total lowland farm area. Generally the irrigated farms produce more per unit area than the non-irrigated farms. Furthermore, planting of two crops a year is possible and better control of weeds and land preparation is facilitated on farms under irrigation. Recently, the construction of the Magat River Irrigation System brought more areas under irrigation. Meanwhile, the non-irrigated areas are entirely dependent upon rain for their water supply.

The introduction of better methods or techniques of planting rice, like the Masagana system by some agencies under the Department of Agriculture and Natural Resources has brought home to farmers the advantages of modern methods of agriculture. Fertilization, the use of insecticides, and the planting of high yielding varieties have also gained acceptance by majority of the farmers. Some farmers, though, seem unappreciative of the scientific methods of agriculture and still cling to their old methods of farming. Farm machinery are now being used by big landowners and tenants who have limited resources retain the carabao and plow as their mainstays for farm tillage.

The level and slightly undulating areas of the San Manuel and Quingua soils along the Cagayan River and its tributaries are usually devoted to clean-culture crops such as tobacco and corn. Inasmuch as these soils are mostly level erosion through runoff is not severe but because of their geographic location with regards to a big body of water like the Cagayan River these soils are subject to inundations as well as stream-bank erosion. On the other hand, the Ilagan sandy loam on the rolling areas is highly erodible. These areas are utilized as pasture lands but due to lack of adequate erosion control measures soil erosion is somewhat excessive in these areas. Pastures are overgrazed and cover cropping is dispensed with to the detriment of the rolling areas and orchards. Green manuring is seldom practiced. In the slightly undulating areas clean-culture cul-

tivation is very common and soil erosion is enhanced; in the rolling to hilly and mountainous areas *kaingin* clearings are numerous. The *kaingin* system of cultivation should be stopped once and for all as vast areas of forest lands are being denuded.

The province of Isabela is relatively well drained. The Cagayan River, flowing from north to south through the entire length of the province, serves as the main drainage artery. The tributaries of this river such as the Ipil, Magat, Siffu, Mallig, Pinacauan de Ilagan, Pinacauan de Tumauini, and Diboluan Rivers provide the network for draining the plains and rolling areas west of the Cagayan River and the plains and foot-hills of the Sierra Madre Mountains east of the same river. While the Cagayan River and its tributaries drain as well as water the land of these same bodies of waters also bring havoc and financial losses to the province due to their periodic overflows. Yearly floods destroy seasonal and permanent crops, sweep away homes, bridges and livestock, deposit gravel, sand and debris over the land, and some productive alluvial lands are lost through stream bank erosion. In passing, it can be said, however, that in many cases the alluvial materials deposited by flood waters on farms along the river banks enriched the soil.

Water control problems which exist in Isabela are just like these besetting other places in the Philippines today. Watershed management, deforestation and reforestation, irrigation systems, etc. could be more effectively governed not only by one or two government agencies, but rather by the cooperative and coordinated efforts of several departments. Cooperative enterprises by communities in the construction of irrigation systems have proven successful in some few places but these cases are more of the exception rather than the rule. For bigger scopes or jobs such as watershed management and forest conservation the national government has started to take steps to minimize floods by instituting controls and better management practices over watersheds and forests. From the grassroots level it is noteworthy that every enlightened citizen has started to realize that kaingin cultivation, indiscriminate logging, overgrazing, and improper use of the land are some of the root causes of floods, soil erosion as well as droughts.

PRODUCTIVITY RATINGS OF THE SOILS OF ISABELA

The productivity ratings of soils are included in the soil survey report to supplement the soil type descriptions and at

the same time present in figures the previous performance of these soils as to crop yields. They also indicate the suitability or unsuitability of the land for a particular crop or set of crops.

The productivity ratings of the soil types of Isabela Province were obtained by the deductive method. Data of crop yields for a long period are considered excellent sources to furnish information on crops and the suitability of a certain soil type for a certain crop. However, such data are seldom compiled by farmers and even government agencies on agriculture have inadequate statistics. The average yields of the different crops on various soils of the province were gathered through inquiries directly from farmers, as well as studies from census, bulletins, and reports of various provincial agricultural officials. These figures are based on local farm practices without the application of commercial fertilizers or amendments.

Table 5 shows the productivity ratings of the soils of Isabela for the major crops grown in the province. The figures indicate that the soils of Isabela Province vary in their production for each of the major crops herein considered. These variations in productivity ratings are significant because they show which of the soil types need improvement.

TABLE 5.—*Productivity ratings of the soils of Isabela.*

	Crop productivity index [1]				
	Upland rice 100=20 cav./ha.	Lowland rice 100=60 cav./ha.	Corn 100=17 cav./ha.	Tobacco 100=1,475 kg./ha.	Mongo 100=7 cav./ha.
Alaminos clay loam					
Bago clay loam		40	40	50	50
Bago sandy clay loam	50	60	50	50	70
Bago sandy loam	50	80	50	50	70
Barog clay loam		120	60	50	80
Bigia clay		50	50	50	80
Cauayan clay		25	50		
Cauayan clay loam			50	50	
Cauayan loam			40	50	
Cauayan sandy loam		30	40	50	
Guimbalaon clay loam	90		100	80	80
Ilagan loam			80	50	60
Guiligua sandy loam			150	70	80
Quingua silty clay loam	100	100	175	80	100
Rugao clay					
Rugao clay loam					
Rugao sandy clay loam			60	70	70
San Juan loam					
San Manuel loam	100	90	176	80	100
San Manuel sandy loam	100		88	25	100
Santa Rita clay loam	100	165	145	100	100

[1] Indexes give approximate average production of each crop in per cent as the standard of reference. The standard represents the approximate yield obtained without the use of fertilizers or amendments from the extensive and better soil types of the regions in the Philippines on which the crop is mostly and widely grown.

TEXTURAL CLASSES OF THE SOILS OF ISABELA

FIELD DETERMINATION OF THE SOIL TEXTURAL CLASS

The determination of the soil textural class is made in the field mainly by feeling the soil with the fingers. While this requires skill and experience, accuracy can be had if the field scientist frequently checks his field textural classification against laboratory results.

Hereunder are definitions and descriptions of the basic soil textural classes in terms of field determination.

Sand.—Sand is loose and single-grained. The individual grains can readily be seen or felt. Squeezed in the hand when dry, individual particles will fall apart when the pressure is released. Squeezed when moist, the particles will form a cast, but will crumble when touched.

Sandy loam.—Sandy loam contains much sand with enough silt and clay to make it somewhat coherent. The individual sand grains can be readily seen and felt. Squeezed when dry, the soil particles will form a cast which readily falls apart, but if squeezed when moist, a cast can be formed which will bear careful handling without breaking.

Loam.—Loam consists of a relatively even mixture of different grades of sand, silt, and clay. It is mellow with a somewhat gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, the soil particles will form a cast that will bear careful handling, while the cast formed by squeezing the moist soil can be handled quite freely without breaking.

Silt loam.—Silt loam contains a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the soil separate called "silt." When dry it may appear cloddy but lumps can be readily broken, and when pulverized it feels soft and floury. When wet the soil readily runs together and puddles. Either dry or moist, the soil particles will form into a cast which can be freely handled without breaking. When moistened and squeezed between the fingers, it will not "ribbon" but will give a broken appearance.

Clay loam.—Clay loam is a fine-textured soil which usually breaks into clods or lumps that are hard when dry. When the moist soil is pinched between the thumb and fingers, it will form a thin "ribbon" which breaks readily, barely sustaining its own weight. The moist soil is plastic and can be formed into a cast that will bear much handling. When kneaded in the hand it does not crumble readily but tends to form into a heavy compact mass.

Clay.—Clay is a fine-textured soil that usually forms very hard lumps or clods when dry, and is quite plastic and usually sticky when wet. When the moist soil is pinched between the thumb and fingers, it will form into a long, flexible "ribbon." Some fine clays very high in colloids are friable and lack plasticity under all conditions of moisture.

The above definitions are descriptive only. None could be made in these or similar terms that would apply adequately to all soils. The dependable definitions, the standards, are those developed from mechanical analysis.

MECHANICAL ANALYSIS

Accuracy in the determination of textural classes of soils delineated during the soil survey is attained through mechanical analysis. Generally, field classifications coincide with the results of the mechanical analyses. However, there are instances when field classification and laboratory classification vary. Some soils exhibit clayey textures in the field. They are sticky and plastic when wet, hard or brittle when dry, but actually when analyzed their clay contents are low. Under these circumstances, the field classifications are maintained except when their clay contents are so low that their final textural classifications are those established by the laboratory.

The soil separates are sand, silt, and clay. Sand includes particles from 2.0 to 0.05 millimeter in diameter; silt from 0.05 to 0.002 millimeter; and clay, particles smaller than 0.002 millimeter in diameter.[1] Particles larger than 2.0 millimeters such as gravels, pebbles, and cobles are considered coarse skeleton. Class names such as sand, silt, silt loam, clay loam, clay, sandy loam, etc., are determined by the proportionate amount of the different separates present in the soil. A soil with an analysis of 30 per cent or more of clay fraction is considered clay soil. Lately, however, this percentage was changed to 40, thus all soils containing 40 per cent or more of clay are classified as clay soils.

The modified Bouyoucos method was employed in the mechanical analysis wherein the conventional jar, hydrometer, and thermometer were used. Analysis was made without removing the organic matter from the soil.

[1] Previous to 1938, the United States Department of Agriculture used the 0.05 to 0.005 millimeter for the size of silt and smaller than 0.005 millimeter for clay.

TABLE 6.—*Average mechanical analysis of the surface soils of the different soil types of Isabela.*[1]

Field determination	Per cent sand 2.0–0.05 mm.	Per cent silt 0.05–.002 mm.	Per cent F. clay below 0.002 mm.	Per cent total colloids	Textural grade (Mech. analysis)
Bago clay loam	37.8	30.8	31.4	48.8	clay loam
Bago clay	58.2	9.8	32.0	37.4	sandy clay loam
Bago sandy loam	69.6	11.8	18.6	24.6	sandy loam
Bantog clay	29.4	33.6	37.0	51.8	clay loam
Bigaa clay	19.2	26.0	54.8	69.8	clay
Cauayan clay	19.0	34.0	47.0	63.0	clay
Cauayan clay loam	29.6	42.0	28.4	----------	clay loam
Cauayan clay loam	39.6	37.8	22.6	39.0	loam
Cauayan sandy clay loam	55.6	28.0	16.4	23.4	sandy loam
Guimbalaon clay loam	27.2	42.0	30.8	47.8	clay loam
Ilagan sandy loam	45.4	38.0	16.6	27.6	loam
Quingua silt loam	23.6	52.0	32.4	50.4	silty clay loam
Rugao clay	35.8	17.0	50.2	55.2	clay
Rugao clay loam	45.0	20.6	34.4	44.6	clay loam
Rugao sandy loam	50.4	23.0	26.6	34.6	sandy clay loam
San Juan loam	49.6	30.0	20.4	----------	loam
San Manuel loam	41.0	34.0	25.0	37.0	loam
San Manuel sandy loam	59.0	29.0	13.0	21.0	sandy loam
Santa Rita clay	38.2	26.8	35.0	39.4	clay loam

[1] The modified Bouyoucos method of analysis was followed.

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF ISABELA

Land capability classification is a scheme of grouping soil types together for their proper utilization. Utilization, from the standpoint of agricultural as well as economic capabilities, implies any of or a combination of four general purposes, namely: (1) cropland, (2) pasture land, (3) forest land, and (4) land for wildlife or recreation. For cropping purposes the crop or set of crops are usually specified and the corresponding necessary soil management practices together with the supporting soil conservation measures are given.

The three major factors to consider in land capability classification are (1) the soil type, (2) the slope of the land, and (3) the degree of erosion. In the consideration of a given soil type, its physical and chemical properties, both of which consist of inherent and acquired characteristics, are fully evaluated in the field and in the laboratory. Land capability classes are further subdivided into subclasses by taking into account different soil problems. In the Philippines, the three major problems on soils are (*a*) erosion and runoff, (*b*) wetness and drainage, and (*c*) root zone and tillage limitations, such as shallowness, stoniness, droughtiness, and salinity. The subclasses are indicated by "e" for erosion and runoff; by "w" for wetness and drainage; and by "s" for root zone and tillage limitations.

The different land capability classes are as follows:

Class A—Very good land; can be cultivated safely; requires only simple but good farm management practices.

Class B—Good land; can be cultivated safely; requires easily applied conservation practices.

Class C—Moderately good land; must be cultivated with caution; requires careful management and intensive conservation practices.

Class D—Fairly good land; must be cultivated with extra caution; requires careful management and complex conservation practices. Best suited to pasture or forest.

Class L—Level to nearly level land; too stony or very wet for cultivation. Suited to pasture or forest with good soil management.

Class M—Steep, very severely to excessively eroded or shallow for cultivation. Suited to pasture or forest with careful management.

Class N—Very steep, excessively eroded, shallow, rough, or dry for cultivation. Suited to pasture with very careful management and definite restrictions. Best suited to forest with very careful management.

Class X—Level land, wet most of the time, cannot be economically drained. Suited for farm ponds or for recreation.

Class Y—Very hilly and mountainous, barren and rugged. Should be reserved for recreation and wildlife.

LAND CAPABILITY CLASS A

Very good land. Can be cultivated safely. Requires only simple but good farm management practices.

Quingua sandy loam	San Manuel loam
Quingua silty clay loam	San Manuel sandy loam

Class A is level to nearly level land. The soil is deep, fertile or well supplied with plant nutrient elements, well drained, and easy to cultivate.

Erosion is not much of a problem. The land is rarely flooded.

This class is suited for intensive cultivation and all crops common in the area can be grown. Since soils under this

class have good permeability, if lowland rice is to be grown, puddling the soil is usually necessary to minimize seepage.

Good farm management practices are required specially the judicious application of agricultural lime and fertilizers and the observance of crop rotation which should include a legume or soil-improving crop in the sequence for sustained production. In consonance with lime and fertilizer application, greater benefits could be derived thereof if green manuring or the plowing under of young green plants, preferably leguminous crops, and the application of farm manure or compost are observed regularly.

Land Capability Class B, Subclass Be

Nearly level to gently sloping, slightly to moderately eroded. Erosion is the main problem. Observe erosion control measures and easily applied conservation practices.

Alaminos Clay Loam

Subclass Be is nearly level to gently sloping land and is slightly to moderately eroded. It is deep with rather heavy subsoil.

The slope, which in any place is not more than 8 per cent, makes the soil susceptible to moderate erosion.

Crops adapted to the area grown on soils of this subclass respond to good management. However, erosion control measures such as contour plowing, terracing, and strip cropping should be practiced. Excess water on the area and runoff from the adjoining uplands must be channeled into grassed waterways or diversion ditches.

In addition to erosion control measures the proper kind and quantity of fertilizer and lime should be applied. Crop rotation should be observed wherein a legume is included in the sequence at least once in every three or four years for soil building purposes. For all legumes, the soil should be well supplied with lime and a phosphate-carrying fertilizer; if the soil does not contain the right kind of bacteria it should be inoculated accordingly. The use of farm manure or compost is recommended.

Land Capability Class B, Subclass Bw

Nearly level, occurs in depressions. Occasional overflow is the problem. Requires protection from overflow. Observe easily applied conservation practices.

Bago clay loam	Bantog clay loam
Bago sandy clay loam	Bigaa clay
Bago sandy loam	Sta. Rita clay loam

Subclass Bw land is nearly level and occurs in depressions near large streams or on low bottom lands. Included under this subclass are wet lands that can be easily drained and those with a high water table. The soil is deep; the subsoil is heavy.

Poor external and internal drainage require some means to drain the excess water. Furthermore, the area is subjected to occasional overflow.

Lowland rice is especially suited to this land. When properly drained, corn, sugar cane, legumes, and other row crops common in the area may be grown.

Protection from occasional overflow of nearby streams may be needed. Diversion ditches should be constructed for runoff coming from adjoining uplands. When drained and cultivated, lime and the right kind and quantity of fertilizer should be applied. The planting of soil-improving crops and the use of farm manure and compost must be observed.

Land Capability Class C, Subclass Ce

Moderately sloping, moderately to severely eroded. Erosion and fertility are the main problems. Observe erosion control measures, careful management and intensive conservation practices.

Bago sandy loam	Guimbalaon clay loam
Cauayan clay	Ilagan loam
Cauayan clay loam	Rugao clay
Cauayan loam	Rugao clay loam
Cauayan sandy loam	Rugao sandy clay loam

Subclass Ce land is moderately sloping and is moderately to severely eroded. Its effective depth may extend to 90 centimeters or more.

The slope which ranges from 8 to 15 per cent accelerates erosion. In turn erosion depletes fertility.

Primarily, for this subclass, a good cropping system should be planned. The crops grown and tillage methods affect soil conditions, and consequently runoff and soil erosion. Different combinations of erosion-prevention and water-control practices should be chosen with the crops to be grown. In general, crops common in the area as well as fruit trees could be cultivated.

Close-growing crops with a legume in the rotation should be supported by practices that control runoff and minimize erosion the most important of which are contour tillage, strip cropping, cover cropping, grassed waterways, and terracing. In addition, lime and fertilizer according to needs, should be applied; compost and farm manure should be incorporated into the soil; and green manuring must be observed regularly.

Land Capability Class D, Subclass De

Strong sloping, severely to very severely eroded. Erosion and fertility are the main problems and the number of years for cultivation limited. Observe erosion control measures; very careful soil management specially good crop rotation, and complex conservation practices if land is to be cultivated. Suited for pasture or forest.

Cauayan clay	Rugao clay
Cauayan clay loam	Rugao clay loam
Cauayan loam	Rugao sandy clay loam
Cauayan sandy loam	San Juan loam
Ilagan loam	

Subclass De is strongly sloping and is severely to very severely eroded land. The topsoil is generally thin; the subsoil is heavy and slowly permeable, subsoil induce moderate to excessive runoff. Consequently, the danger of soil erosion is increased. The topsoil being thin, accelerated erosion on this land will be very critical both on the standpoint of effective soil depth and fertility. The lack of soil depth for good root penetration and water intake storage are added problems to cope with.

To farm this land safely very careful and good soil management practices should be observed. Subclass De land has definite restrictions and the choice of use is reduced. Planting of row crops is not advisable. When close growing crops are planted a well planned rotation should be followed, planting should be along the contour, and before full growth is attained by the plants mulching is necessary. On the higher slopes a system of properly laid out terraces should be constructed with suitable outlets installed in the absence of natural outlets. Terrace outlets must have vegetable cover, preferably grass, at all times. If grass is not well established, reseeding and fertilizing should be done. All hazards induced by tillage and runoff should be properly appraised and supporting conservation practices instituted accordingly.

When used for orchards contour planting should be observed and a good stand of leguminous cover crop should be maintained. Deep-rooted legumes improve subsoil structure. They keep the subsoil porous for water, roots, and air to get through readily.

Where erosion on a moderately deep soil is not severe, gullies should be smoothened and then seeded to grass or legumes. The soil should be limed and fertilized to give the grass or legume a good start; the legume seeds will need inoculation.

It is best suited to pasture or forest.

Land Capability Class D, Subclass Ds

Nearly level to gently sloping, slightly eroded.. Very low fertility, very rapid permeability and low moisture holding capacity, strongly alkaline or high salt content, formation of dunes is/are the problem/s. Adopt special soil management practices and observe complex conservation practices if land is to be cultivated.

Beach sand

Subclass Ds is nearly level to gently sloping land and is slightly eroded. The surface soil is shallow with sandy to loamy texture; the subsoil is highly permeable.

Relatively, subclass Ds land may be less sloping than subclass Cs land, but for root zone and tillage limitations, the former has more acute problems than the latter. Thus, Ds land is comparatively of lower fertility, or has a more rapid permeability and lower moisture holding capacity, or has a higher salt content than Cs land. Moreover, the formation of dunes through wind action is more likely to happen on land under subclass Ds.

If planted to clean culture crops soils under this subclass require intensive conservation measures. This subclass may be devoted to vegetables or to truck farming and to root crops provided water supply is adequate and additional measures are taken to increase the water holding capacity of the soil.

Increasing the organic matter content of the soil by the application of compost and farm manure and the observance of green manuring are necessary. Other vegetative soil conservation measures to be instituted in conjunction with clean culture cultivation are contour and buffer strip cropping, cover cropping and mulching. Where sand dunes are likely to form vegetative and mechanical means to stabilize the shifting sand must be adopted.

It is not likely that soil under this subclass will need any lime but should it be deemed necessary lime may be added only after the soil is analyzed. Commercial fertilizers needed would be more of nitrogenous fertilizer for leafy vegetables and ammonium phosphate or complete fertilizers, as soil analysis may show, for the fruiting vegetables.

Land Capability Class M

Steep, very severely to excessively eroded, or shallow for cultivation. Suited to pasture or forest with careful management.

Alaminos clay loam	Ilagan loam
Cauayan clay	Rugao clay
Cauayan clay loam	Rugao clay loam
Cauayan loam	Rugao sandy clay loam
Cauayan sandy loam	San Juan loam

Class M is steep and is very severely to excessively eroded, or shallow land. Stones or gravels may be present.

The slope, which ranges from 25 to 40 per cent, and the generally shallow soil make this land unfit for seasonal cultivation. Where climatic conditions are favorable orchards of citrus, coffee, etc., may be developed provided the trees are planted along the contour and a good cover crop is raised to prevent soil erosion.

Land under this capability class is best suited to pasture or forest. When devoted to pasture careful management should be observed. To grow legumes or grass for grazing the soil should be well prepared. Lime and fertilizers, as needed, should be applied to give the young legumes or grass a good start. Newly developed pastures should not be grazed heavily; the use of those already established should be controlled and rotated. Stock ponds should be constructed wherever possible. Diversion terraces around the heads of active gullies should be installed. Gullies that are about to develop should be smoothed and sodded.

For forest purposes, trees should be protected from fires; *kaingin* cultivation must be prevented; bare space should be planted to trees like *ipil-ipil.*

Land Capability Class N

Very steep, excessively eroded, shallow, rough or dry for cultivation. Suited to pasture with very careful management and definite restrictions. Best suited to forest with very careful management and restrictions.

Ilagan loam	San Juan loam

Class N is very steep and is excessively eroded land. The soil is very shallow and dry; the land is rugged and broken by many large gullies.

The slope, which is 40 per cent or over, and excessive erosion make this land not suitable for cultivation.

Land under this capability class could be utilized for pasture provided very careful management is observed and definite restrictions imposed. Where grasses grow, grazing must be controlled or restricted to a few heads of animals per hectare and grazing areas rotated regularly. The pasture will need liberal application of fertilizers and lime; reseeding is necessary.

This land is best suited to forest. However, very careful management and restrictions must be observed. The establishment of permanent vegetation, like *ipil-ipil,* is recommended especially in gullied places. *Kaingin* farming must be stopped by all means.

Land Capability Class X

Level land, wet most of the time and cannot be economically drained. Can be used for farm ponds or for recreation.

Hydrosol

Class X is level or slightly depressed land and because of its location and elevation sea water or fresh water finds passage into the area. In some places the water may flow or drain back to its source with the receding tide while in others the water stagnates. Land along the shore or very near the sea and at the mouths of rivers and creeks which are accessible to sea water are usually covered by mangroves or nipa palms. Inland areas occupied by fresh water, on the other hand, are covered by grasses. In general, land covered by sea or fresh water part or most of the time is known as a hydrosol area.

This land is suitable for salt beds, fish ponds, farm ponds, or recreation, as the case may be.

In the construction of fish ponds or salt beds the trees and palms are cut except a strip along the shore line wide enough to protect the site from the scouring action of waves. For fish ponds the site should be dug no less than a meter deep. Afterwards, the water should be fertilized to produce a good growth of algae, the food for most fish.

Land Capability Class Y

Very hilly or mountainous, barren and rugged. Should be reserved for recreation and wildlife.

Mountain soils, undifferentiated

Class Y is extremely arid or very steep, rough and stony land with very thin or no soil cover at all. It includes such areas as rocky foot-hills, rough mountainous lands; large areas dotted with rock outcrops or strewn with boulders; and extremely eroded places with exposed substrata.

Land under this capability class is recommended for wildlife and recreation. By all means, existing forests should be preserved; as much as possible, where non-existent, permanent forest vegetation should be established.

TABLE 7.—*Land capability classification of each soil type or miscellaneous land type in Isabela.*

Soil type, miscellaneous land type number	Soil type or miscellaneous land type	Possible Soil Unit[1] (Slope-erosion)	Land capability Class
412	Quingua sandy loam	a–0	A
285	Quingua silty clay loam		
190	San Manuel loam		
96	San Manuel sandy loam		
407	Alaminos clay loam	b–0	Be
410	Bago clay loam	a–0	Bw
262	Bago sandy clay loam		
548	Bago sandy loam		
16	Bantog clay loam	b–0	
192	Bigaa clay		
119	Santa Rita clay loam		
548	Bago sandy loam	c–2	Ce
280	Guimbalaon clay loam		
118	Beach sand		Ds
398	Cauayan clay	c–2	Ce
397	Cauayan clay laom		
622	Cauayan loam		
396	Cauayan sandy loam		
903	Ilagan loam	c–3	De
400	Rugao clay	d–4	M
401	Rugao clay loam		
824	Rugao sandy clay loam		
874	San Juan loam		
407	Alaminos clay loam	d–4	M
903	Ilagan loam	f–5	N
874	San Juan loam		
1	Hydrosol		X
45	Mountain soils, undifferentiated		Y

[1] The slope–erosion units are possible conditions that may exist in each soil type. Any other unit with a slope or an erosion greater than the ones specified in the table will accordingly be classified under a lower capability class.

SOME CHEMICAL CHARACTERISTICS OF THE SOILS OF ISABELA PROVINCE

Z. P. Ventura, G. B. Querijero & R. Samaniego[1]

INTRODUCTION

The province of Isabela, located in Luzon, is bounded in the north by Cagayan, in the west by Mountain Province, in the south by Nueva Vizcaya and a small part of Quezon Province and in the east by the Pacific Ocean. There are twenty-one soil types and three miscellaneous land types mapped. However, only twenty (20) soil types were available for chemical analyses. Nine soil types classified occur in the plains. These are secondary soils with level relief which were developed from the transported materials by the overflowing rivers.

Cattle raising contributes to a certain extent to the income of the people. *Kaingin* cultivation still exists in small patches in the virgin lands. In some places, though, the Masagana system of planting rice has been popularized. Irrigated and non-irrigated farms constitute the lowland farm area which is one-half of the total farm area. The Magat River Irrigation System has recently been constructed. Some other farm practices which have gained acceptance among many farmers include: the control of weeds; fertilization; the use of insecticides; the planting of high yielding varieties; farm machineries being used by big land owners; cover cropping practiced by the farmers in rolling areas; and the recognition that erodible rolling areas are best suited to pasture.

There are only two cropping seasons a year. The important crops of Isabela are tobacco, rice, corn, fruits, vegetables, root crops, sugar cane and coffee.

The studies on the chemical characteristics of twenty out of the twenty-one soil types of Isabela include organic matter; the available constituents, i.e., nitrogen as ammonia and as nitrate, phosphorus, potassium, calcium, magnesium, and man-

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ganese; the exchangeable phosphate; and the pH values in three different mediums (water, 1 N KCl at pH 7, and 1 N NaAc at pH 7).

The soil provides plants with a supply of the essential elements as well as of the trace elements. If the plants are not supplied with the proper amounts of these elements, they exhibit symptoms which are called by soil workers as "deficiency symptoms."

It happens sometimes that when proper amounts of these elements are present in the soil the plants still show these "deficiency symptoms." This occurs when one or more elements are "unavailable" to plants. This can happen in a number of ways. On one hand, the element or elements present may be in their insoluble forms; on the other hand, the element or elements may be lost by leaching, run-off, evaporation or are absorbed by weeds.

ANALYTICAL METHODS

The method used for the analysis of available nitrogen as ammonia and nitrate is the Spurway method.[1] Available phosphorus is analyzed by the Truog method[2] and the exchangeable phosphate by the method described by Piper using 1 N NaOH as the displacing solution.[3] The available potassium, calcium, magnesium and manganese were analyzed by the rapid microchemical tests described by Peech and English.[4] Total organic matter was analyzed by the modified method of Walkley and Black.[5] The pH values of the soil samples in three mediums were determined with a Beckman Zeromatic pH meter. The three mediums were water, 1 N KCl (pH 7), and 1 N NaAc (pH 7) at a 1:1 ratio with the soil.

[1] C. H. Spurway, "Soil Testing, A Practical System of Chemical Diagnosis," *Michigan Agricultural Experiment Station, Technical Bulletin 132*, (Michigan, 1948).

[2] E. Truog, "The Determination of the Readily Available Phosphorus of Soils." *Jour. Amer. Soc. Agron., 22*: 874–882 (1930).

[3] C. S. Piper, *Soil and Plant Analyses*, (N. Y.: Interscience, Inc., 1950), p. 195.

[4] M. Peech and L. English, "Rapid Microchemical Soil Test," *Soil Science, Vol. 57:* 167–195 (1944).

[5] A. Walkey and I. A. Black, "Determination of Organic Matter in Soils," *Soil Science, 35:* 29–28 (1947).

RESULTS AND INTERPRETATIONS

Nitrogen.[6]—The available ammoniacal nitrogen as expected is small and the nitrates hardly appear in the soil,[7] so that higher plants growing on such a soil may, therefore, suffer from a lack of available nitrogen.[8] However, this is not always undesirable.[9] It is, in fact, at times desired since nitrogen is held in complex combinations and thus not susceptible to loss in drainage. This is nature's way of providing a method of nitrogen control and conservation that is highly efficient.[10]

Phosphorus.[11]—Although the amount of total phosphorus in an average mineral soil is similar to that of nitrogen, it is available in much lower amounts than potassium, calcium or magnesium. Of even greater importance, however, is the fact that most of the phosphorus present in soils is unavailable to plants. Also, when the soluble sources of this element are supplied to soils in the form of fertilizers their phosphorus is often 'fixed' or rendered unavailable even under the most ideal field conditions.[12]

Total phosphorus is roughly made up of the available or soluble, the exchangeable or reserved phosphorus and phosphorus tied up in insoluble forms. Column 7 of table 8 shows the status of the readily available phosphorus. Comparing this to the range of P_2O_5 that may ordinarily be expected (i.e., 20 ppm to 40 ppm), it is seen that phosphorus level is below the desired range for some soils. Only nine soil types have a satisfactory level of available phosphorus. Column 12 of the same table shows the amount of exchangeable phosphate in milliequivalents per 100 grams of soil. The amounts of these ex-

[6] For a discussion of nitrogen as a major plant nutrient and its relationship with other nutrients, see: G. B. Querijero and R. T. Marfori, "Some Chemical Characteristics and Fertilizer Requirements of the Soils of Cebu Province," (*Philippine Journal of Soils*, at the press).

[7] See Column 5 and Column 6 of table 8.

[8] Lyon & Buckman, *Nature and Properties of Soils*, Macmillan Co., New York, 4th ed. p. 136. 1947.

[9] Waksman, S. A. & Hutchings, I. J., "The Role of Plant Constituents in the Preservation of Nitrogen in the Soil," *Soil Sci. XL*, 487–497, 1935

[10] *Ibid*, Lyon & Buckman, p. 37.

[11] For a lengthy discussion of phosphorus as a plant nutrient and factors affecting its availability, see Afaga, E. A., G. B. Querijero, and R. Samaniego, "Chemical Characteristics of the Soils of Camarines Norte," *Soil Report No. 23*.

[12] Lyon, Buckman and Brady, *Nature and Properties of Soils*, MacMillan Co. N.Y. p. 472. 1962.

changeable phosphates as expected is higher than the available phosphorus, since most of the phosphates might have been fixed by the soluble iron, aluminum and manganese ions for those soil types with pH between 5.5 and below and for those with pH 5.5 and above by calcium and magnesium as the phosphates and biphosphates are fixed by the hydrous oxides of iron, aluminum and manganese.

Potassium, Calcium and Manganese.[13]—The total amounts of potassium, calcium and magnesium are made up largely of their available or soluble, and their exchangeable or reserved forms. It is not always true, however, that the amount of exchangeable nutrient must always exceed that of the available form.[14] The availability of adsorbed nutrients is not always so easy to assess. This is because several factors operate to expedite or retard the release of nutrients to plants. These factors are (1) cation saturation, (2) influence of associated ions, (3) effect of the type of colloid, and (4) influence of the replacing cation.

If the exchange resistance of displacing cations is of the order H>Ca and Mg>K and Na; and if a uniform type of colloidal micelle is involved and the influence of any replacing cation; rainfall and humidity is reduced to nil, then we expect K bonding to break off more easily and that of H and Ca and Mg less easily. A high potassium exchange capacity but a low level of potassium in solution may also occur. Sometimes calcium and magnesium exchange capacities are low but Ca availability is at a satisfactory level. The type of clay mineral that is mostly present in the soils as well as the rainfall and humidity of the region might be some reasons for such result.[15] The colloidal complex in the soil gradually develops a calcium-hydrogen complex with an acidity in rough proportion to the dominance of the entering hydrogen ions. The entering hydrogen ions might be from the organic matter present. Organic matter, when soil processes are fully initiated, liberates carbonic acid and other minor acids like the amino acids, sulfuric and phosphoric acids. Hydrogen ions, then, forces part of the calcium out. This

[13] For a lengthy discussion of these elements as plant nutrient and their relationship's with other nutrients, see Marfori, R. T. & I. V. Villanueva, "The Chemical Characteristics of the Soils of Ilocos Sur Province," (at the press).

[14] *Ibid* Lyon, Buckman and Brady, p. 116.

[15] *Ibid*, Lyon, Buckman & Brady, p. 87.

explains that while the pH values are low, availability of calcium is high. These explain the results on columns 8, 9 and 10 of the table.

Manganese.[16]—A careful study of column 14 of the table shows the availability of manganese, contrary to expectations,[17] to be low, although the soils are generally acidic as shown in column 1. This could mean that to start with, this element might be lacking in the soil.

"If the soil reaction is held within two soil pH ranges, say 6.0 to 7.0, the toxicity of aluminum, iron and manganese may satisfactorily be suppressed, at the same time, their transformation into unavailable from will be avoided unless these elements beforehand are decidedly lacking in the soil."[18]

pH,[19] *Soil Solution: Free and Reserved Acidity.*—In an acid soil, two groups of hydrogen ions are involved—those of the soil solution itself and those held as adsorbed cations by the colloidal complex.[20] These groups are in dynamic equilibrium and consequently both must be considered in any attempt to alter the H^+ to OH^- ratio of the soil solution. Soil pH exhibits minor fluctuations due mostly to fluctuating microbial activities. Soil solution is the liquid phase (or water) in soils which contains dissolved salts. In considering the hydrogen-ion concentration of the soil solution it is not to be inferred that one is dealing with an ordinary homogeneous solution. In fact, because of adsorption, the exact opposite is true. For example, the H-ions are concentrated near the colloidal interfaces and become less numerous as the distance from the micelle increases. The attractive forces of the colloidal surfaces are such as to make the differences in hydrogen-ion concentration between the inner and outer layers of the capillary water, in most cases, very great, indeed. As a result, the drainage water even from a markedly acid soil may be near neutral due in part to this heterogeneity of the soil solution. In correcting the acidic condition of the soil solution, it is important to bear in mind that its potential

[16] For a detailed description of manganese as a plant nutrient and its availability see Afaga, E. A., Querijero, G. B., Samaniego, R., "Chemical Characteristics of the Soils of Camarines Norte," *Soil Report No. 23.*

[17] Refer to Pettinger's Chart, Lyon Buckman & Brady, p. 405.

[18] *Ibid*, Lyon, Buckman & Brady, p. 403.

[19] For the comparison of the relative strengths of 3 extracting media, see columns 1, 2 & 3 of table 1.

[20] *Ibid*, Lyon, Buckman & Brady, pp. 395–399.

(or reserved) acidity must be neutralized first before the pH of the soil solution can be changed appreciably. This is due to the buffering capacity of soils, the cation exchange capacity, and the per cent base saturation of colloidal complexes and silicate minerals. This explains the result obtained that although sometimes the soil solution is acidic the base saturation is high, and exchangeable hydrogen low.

A marked change in pH undoubtedly indicates a radical modification in soil environment, especially with respect to the availability of plant nutrients.[21] Furthermore, if this environment should fluctuate too widely higher plants and microorganisms undoubtedly would suffer seriously before they could make adequate adjustments. So important is the maintenance of a proper acidity environment that Pettinger in 1955 published a chart for use with mineral soils which indicates the relative availability of some of the plant nutrients at various degrees of soil acidity.[22]

Anion Exchange (exchangeable phosphorus).—Of the plant nutrient anions, only phosphate shows much anion exchange in soils.[23] Sulfate may exchange some, but chlorides and nitrates. little or none at all. Phosphorus in an exchangeable form is fixed by silicate minerals (i.e., kaolinite, montmorillonite and illite) or is fixed by simpler iron and aluminum compounds. Although there is some doubt as to the actual mechanism involved there are some workers who believe that chemical bonding of a double decomposition nature, rather than physical (the usual adsorption) bonding is responsible for the fixation. There are some workers, on the other hand, who visualize the fixation of the phosphates by silicate minerals as a surface reaction between exposed OH groups on the mineral crystal and the H_2PO_4 ions.[24] The displacement of the OH group in a mineral with $H_2PO_4^-$ is known as anion exchange since one anion is replaced with another anion. Anion exchange is analogous to cation exchange. Adsorbed cations are released relatively easier to plants or to the soil solution. Adsorbed phosphorus,

[21] *Ibid*, Lyon, et al., p. 401.

[22] N. A. Pettinger, "A Useful Chart for Teaching the Relation of Soil Reaction to the Availability of Plant Nutrients to Crops," Va., *Bull. 136*, (1935).

[23] M. L. Jackson, *Soil Chemical Analysis*, (N. Y.: Prentice-Hall, 1958), p. 57.

[24] *Ibid*, Lyon, Buckman and Brady.

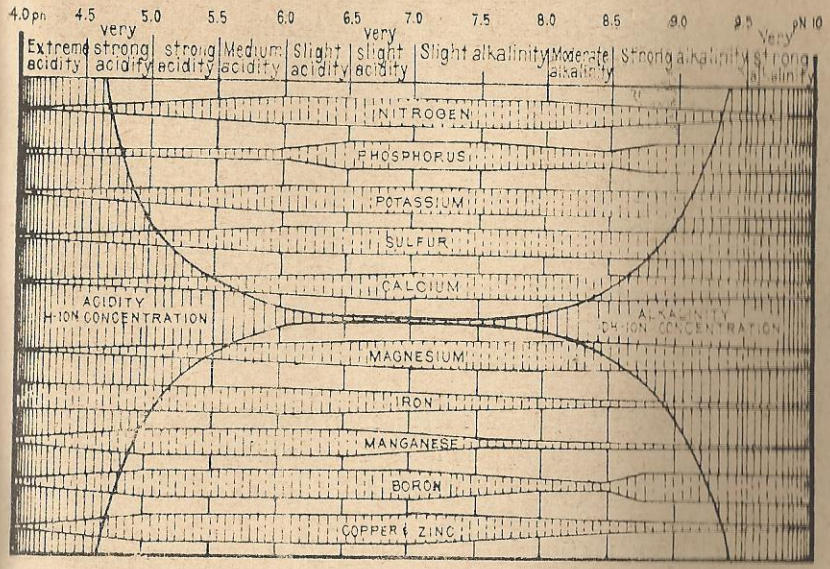

Figure 28. Chart showing the general trend of relation of reaction to availability of plant nutrients.

however, is very tightly held and is only sparingly available to plants. Undoubtedly, the process has considerable practical significance in that liming, which furnishes OH-ions, tends to bring about the release of some fixed phosphorus. Also, liming reduces to a marked degree the fixation of the phosphates as iron and aluminum compounds.

FERTILIZER AND LIME REQUIREMENTS

The application or use of fertilizers in cultivated soils for increased crop production started much later than the incorporation of animal excrements into the soils. Nowadays, the application of manures and fertilizers, whether organic or inorganic, becomes an economic necessity for soils. The use of lime to correct soil acidity is also becoming a common practice.

Nitrogen, phosphorus and potassium are mostly contained in commercial fertilizers so that they are also referred to as fertilizer elements. These fertilizer elements check, balance, support and supplement one another and other nutrient elements when properly used. It is necessary that the correct proportion of these fertilizer elements be present in the soil otherwise abnormal crop growth may result.

On the basis of these fertilizer elements, a general grouping of the sources of fertilizer materials would be: (1) those that supply nitrogen, (2) those that are sources of phosphorus, and (3) those that are potassium carriers.

For those that supply nitrogen, they can be further subdivided into the organic and inorganic sources. Garbage tankage, animal tankage, fish scrap, dried blood, tobacco stems and midribs, castor meals are some examples of organic nitrogen carriers. They contain varying amounts of nitrogen ranging from 1% to 10%. The inorganic nitrogen carriers are ammonium sulfate, ammonium nitrate, nitrate of soda, urea, ammonium phosphate, anhydrous ammonia, etc., varying in nitrogen content from 3% to 8%.

The common phosphatic fertilizer materials are the superphosphates, ammonium phosphate, rock phosphate, basic slag, calcium metaphosphate, etc., varying in amounts of from 12% to 63% P_2O_5.

The fertilizer materials carrying potassium are muriate of potash, potassium sulfate, kainit, potassium nitrate, sulfate of potash-magnesia, etc., containing potash in amounts ranging from 12% to 60%.

The importance of the use of lime to correct the acidity of the soil must not be overlooked. Agricultural lime, calcium carbonate pulverized to 20 mesh and 50% of which should pass through 100 mesh, is commonly used.

The soils of Isabela also require fertilizer applications in order to increase or improve their fertility status for maximum crop returns.

Table 9 gives the amounts of the different fertilizers and lime requirements of Isabela soils for some crops.

For tobacco, the required amounts of lime, superphosphate and sulfate of potash are the same for the native and Virginia varieties. However, for ammonium sulfate application, Virginia tobacco requires a lower amount than native tobacco. The amounts of agricultural lime to be used for the different soil types range from 0.25 to 4.25 tons per hectare; of superphosphate, 150 to 350 kilograms per hectare; and sulfate of potash, 60 to 720 kilograms per hectare. For ammonium sulfate, native tobacco would require 50 to 200 kilograms per hectare and Virginia tobacco, 50 to 150 kilograms per hectare. However, some soils contain these major elements in sufficient levels to support plant growth so that they do not require the application of com-

TABLE 8.—*Some chemical characteristics of the soil types of Isabela Province.*

Soil type	pH Value (1:1, H_2O soil) (1)	pH Value (1N KCl pH = 7) (2)	pH Value (1N NaOAC pH = 7) (3)	Total organic matter (4)	Available constituents (parts per million) NH_3 (5)	NO_3 (6)	P (7)	K (8)	Ca (9)	Mg (10)	Mn (11)	Exchangeable phosphates (Meq/100 gm soil) (12)
Alimodian clay loam	7.10	6.30	7.60	1.70	2	trace	11	200	3,300	1,875	212	20.25
Bago sandy clay loam	7.35	6.30	7.50	3.51	trace	trace	350	151	3,500	1,685	63	21.75
Bago clay loam	5.75	5.20	6.85	1.35	2	trace	42	185	2,800	618	169	13.94
Bago sandy loam	6.10	5.60	7.40	0.17	2	trace	6	151	900	375	63	10.65
Bantog clay loam	6.50	5.60	6.50	3.64	trace	trace	19	135	2,400	680	195	15.20
Bugan silt	6.55	5.20	6.20	5.06	trace	trace	180	200	3,300	1,875	107	17.70
Cauayan clay	4.70	5.10	5.25	5.52	2	2	12	245	1,900	675	203	0.90
Cauayan clay loam	6.20	5.90	6.80	3.44	10	trace	1	167	1,700	750	212	20.25
Cauayan sandy loam	6.60	5.70	6.05	0.96	trace	trace	4	167	1,000	678	160	23.60
Cauayan clay loam	4.80	3.90	4.50	2.11	25	10	trace	trace	200	15	trace	12.89
Dagan loam	5.30	4.80	5.50	1.58	trace	trace	52	220	2,700	678	63	16.78
Dumaran sandy loam	5.70	5.30	6.40	2.75	trace	trace	100	151	1,500	1,875	37	25.70
Dumaran silty clay loam	6.70	6.10	7.10	2.05	trace	20	580	151	4,000	1,130	63	15.20
Ilagan clay	6.60	5.30	6.90	0.76	25	10	trace	trace	200	15	trace	12.89
Ilagan clay loam	6.50	5.80	6.50	0.66	2	25	22	151	900	558	142	18.00
Ilagan sandy clay loam	5.75	5.10	6.30	1.20	trace	trace	6	167	700	510	186	10.26
San Manuel loam	5.70	6.40	7.20	2.25	trace	trace	315	200	3,300	1,130	32	18.15
San Manuel sandy loam	5.80	5.30	6.10	0.44	trace	2	350	185	3,200	1,130	56	10.84
San Juan loam	7.10	6.30	7.60	1.73	10	trace	7	167	800	339	18	10.65
Santa Rita clay loam	5.00	5.10	5.90	1.07	10	trace	220	167	2,600	1,250	160	23.85

plete fertilizers. With such soils, only single element fertilizers will do.

Fertilizer and lime requirements are also given for lowland and upland rice. For soils needing agricultural lime application the amounts for upland rice are double those for lowland rice. The amounts, therefore, for lowland rice range from 0.25 4.50 tons per hectare and for upland rice, 0.50 to 9.00 tons per hectare. The required amounts for ammonium sulfate, superphosphate and muriate of potash are the same for lowland and upland rice. The soils need an application of 100 to 200 kilograms per hectare of ammonium sulfate, 150 to 350 kilograms per hectare of superphosphate and 50 to 300 kilograms per hectare of muriate of potash.

Recommendations for corn are also given. The amounts of agricultural lime application range from 0.50 to 9.00 tons per hectare; ammonium sulfate, 100 to 300 kilograms per hectare; superphosphate, 150 to 350 kilograms per hectare; and, muriate of potash, 50 to 450 kilograms per hectare.

For peanut, agricultural lime applications range from 0.50 to 9.00 tons per hectare; ammonium sulfate, only 100 kilograms per hectare for all soils; superphosphate, 150 to 350 kilograms per hectare; and, muriate of potash, 50 to 300 kilograms per hectare.

TABLE 9.—*Fertilizer and lime requirements of soils from Isabela Province.*

Area represented by	Agricultural lime	Ammonium sulfate (20% N)	Superphosphate (20% P_2O_5)	Sulfate of potash (50% K_2O)
	For Tobacco	(Native)		
Alaminos clay loam		200	250	
Bago sandy clay loam		200		60
Bago clay loam		200		
Bago sandy loam	2.75	200	300	60
Bantog clay loam		200	150	120
Bigaa clay		200		
Cauayan clay	0.25	200	250	
Cauayan clay loam	0.75	200	350	60
Cauayan sandy loam	2.50	200	300	60
Guimbalaon clay loam	4.50		350	720
Ilagan loam		200		
Quingua sandy loam	1.25	200		60
Quingua silty clay loam		100		60
Rugao clay	4.50		350	720
Rugao clay loam	2.75	50	150	60
Rugao sandy clay loam	3.25	200	300	60
San Manuel loam		200		
San Manuel sandy loam		200		
San Juan loam	3.00	200	300	60
Santa Rita clay loam		200		9

TABLE 9.—*Fertilizer and lime requirements of soils from Isabela Province.*—Continued

Area represented by	Agricultural lime	Ammonium sulfate (20% N)	Superphosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	For tobacco (Virginia) [1]			
Alaminos clay loam		150	250	
Bago sandy clay loam		150		60
Bago clay loam		150		
Bago sandy loam	2.75	150	300	60
Bantog clay loam		150	150	120
Bigaa clay		150		
Cauayan clay	0.25	150	250	
Cauayan clay loam	0.75	150	350	60
Cauayan sandy loam	2.50	150	300	60
Guimbalaon clay loam	.450		350	720
Ilagan loam		150		
Quingua sandy loam	1.25	150		60
Quingua silty clay loam		50		60
Rugao clay	4.50		350	720
Rugao sandy clay loam	3.25	150	300	60
Rugao clay loam	2.75		150	60
San Manuel loam		150		
San Manuel sandy loam		150		
San Juan loam	3.00	150	300	60
Santa Rita clay loam		150		60
	For rice (lowland)			
Alaminos clay loam		200	250	
Bago sandy clay loam		200		50
Bago clay loam		200		
Bago sandy loam	2.75	200	300	50
Bantog clay loam		200	150	50
Bigaa clay		200		
Cauayan clay	0.25	200	250	
Cauayan clay loam	0.75	200	350	50
Cauayan sandy loam	2.50	200	300	50
Guimbalaon clay loam	4.50		350	300
Ilagan loam		200		
Quingua sandy loam	1.25	200		50
Quingua silty clay loam		100		50
Rugao clay	4.50		350	300
Rugao clay loam	2.75		150	50
Rugao sandy clay loam	3.25	200	300	50
San Manuel loam		200		
San Manuel sandy loam		200		
San Juan loam	3.00	200	300	50
Santa Rita clay loam		200		50
	For rice (upland)			
Alaminos clay loam		200	250	
Bago sandy clay loam		200		50
Bago clay loam		200		
Bago sandy loam	5.50	200	300	50
Bantog clay loam		200	150	50
Bigaa clay		200		
Cauayan clay	0.50	200	250	
Cauayan clay loam	1.50	200	350	50
Cauayan sandy loam	5.00	200	300	50
Guimbalaon clay loam	9.00		350	300
Ilagan loam		200		
Quingua sandy loam	2.50	200		50
Quingua silty clay loam		100		50
Rugao clay	9.00		350	300
Rugao clay loam	5.50		150	50
Rugao sandy clay loam	6.50	200	300	50
San Manuel loam		200		
San Manuel sandy loam		200		
San Juan loam	6.00	200	300	50
Santa Rita clay loam		200		50

[1] For tobacco, Sulfate of Potash (50% K_2O) instead of Muriate of Potash (60% K_2O) should be used.

TABLE 9.—*Fertilizer and lime requirements of soils from Isabela Province.*—(Continued)

Area represented by	Agricultural lime	Ammonium sulfate (20% N)	Superphosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	For corn			
Alaminos clay loam		300	250	
Bago sandy clay loam		300		50
Bago sandy loam	5.50	300	300	50
Bago clay loam		300		
Bantog clay loam		300	150	100
Bigaa clay		300		
Cauayan clay	0.50	300	250	
Cauayan clay loam	1.50	300	350	50
Cauayan sandy loam	5.00	300	300	50
Guimbalaon clay loam	9.00		350	450
Ilagan loam		300		
Quingua sandy loam	2.50	300		50
Quingua silty clay loam		150		50
Rugao clay	9.00		350	450
Rugao clay loam	5.50	100	150	50
Rugao sandy clay loam	6.50	300	300	50
San Manuel loam		300		
San Manuel sandy loam		300		
San Juan loam	6.00	300	300	50
Santa Rita clay loam		300		50
	For peanut			
Alaminos clay loam		100	250	
Bago sandy clay loam		100		50
Bago clay loam		100		
Bago sandy loam	5.50	100	300	50
Bantog clay loam		100	150	50
Bigaa clay		100		
Cauayan clay	0.50	100	250	
Cauayan clay loam	1.50	100	350	50
Cauayan sandy loam	5.00	100	300	50
Guimbalaon clay loam	9.00		350	300
Ilagan loam		100		
Quingua sandy loam	2.50	100		50
Quingua silty clay loam				50
Rugao clay	9.00		350	300
Rugao clay loam	5.50		150	50
Rugao sandy clay loam	6.50	100	300	50
San Manuel loam		100		
San Manuel sandy loam		100		
San Juan loam	6.00	100	300	50
Santa Rita clay loam		100		50

GLOSARRY OF COMMON ECONOMIC PLANTS FOUND IN ISABELA

Common Name	Scientific Name	Family
Abaca	*Musa textilis Nee*	Musaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Apitong	*Dipterocarpus grandiflorus* Blco.	Dipterocarpaceae
Avocado	*Persea americana* Mill.	Lauraceae
Bagtican	*Parashorea malaanonnan* (Blco.) Merr.	Dipterocarpaceae
Bakauan-babae	*Rhizophora mucronata Lam.*	Rhizophoraceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Banana	*Musa sapientum* Linn.	Musaceae
Betel nut	*Areca catechu* Linn.	Palmae
Breadfruit	*Artocarpus communis Forst*	Moraceae
Buri	*Corypha elata* Roxb.	Palmae
Cabbage	*Brassica oleracea* Linn.	Cruciferae
Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Camote	*Ipomoea batatas* Linn.	Convolvulaceae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Canistel	*Lucuma nervisa* A.D.C.	Sapotaceae
Cassava	*Manibot esculenta* Crantz	Euphorbiaceae
Chico	*Achras sapota* (Jacq.) Merr.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Cogon	*Imperata cylindrica* (Linn.) Beauv	Gramineae
Coffee-arabica	*Coffea arabica*	Rubiaceae
Corn	*Zea mays* Linn.	Gramineae
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceae
Dayap	*Citrus aurantifolia* (Christm.) Swingle	Rutaceae
Duhat	*Eugenia cumini* (Linn.) Druce	Myrtaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculenta* (Linn.) Schott & Endl.	Araceae
Garlic	*Allium sativum* Linn.	Liliaceae
Guava	*Psidium guajava* Linn.	Myrtaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Guijo	*Shorea guiso* (Blco.) Blm.	Dipterocarpaceae
Ipil-Ipil	*Leucaena glauca* (Linn.) Benth	Leguminosae
Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
Kalamansi	*Citrus microcarpa* Bunge	Rutaceae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Kamachile	*Pithecolobium dulce* (Roxb.) Benth	Leguminosae
Kapok	*Ceiba pentandra* (Linn.) Gaertn	Bombacaceae
Katurai	*Sesbania grandiflora* (Linn.) Pers.	Leguminosae

Common Name	Scientific Name	Family
Kondol	*Benincasa hispida* (Thumb) Cogn.	Cucurbitaceae
Lanzones	*Lansium domesticum* Correa	Meliaceae
Lumbang	*Aleurites moluccana* Willd.	Euphorbiaceae
Mabolo	*Diospyros discolor* Willd.	Ebenaceae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Mungo	*Phaseolus aureus* Roxb.	Leguminosae
Narra	*Pterocarpus indicus* Willd.	Leguminosae
Nipa	*Nypa fruticans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Palosapis	*Anisoptera thurifera* (Blanco) Blume	Dipterocarpaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Para rubber	*Hevea brasilliensis* (HBK) Muell. Arg.	Euphorbiaceae
Patola	*Luffa cylindrica* (Linn.) M. Roem-	Cucurbitaceae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Pepper	*Capsicum annuum* Linn.	Solanaceae
Pili nut	*Canarium luzonicum* (Blm.) A. Gray	Burseraceae
Pineapple	*Ananas comosos* (Linn.) Merr.	Bromeliaceae
Pumelo	*Citrus maxima* (Burm.) Merr.	Rutaceae
Rattan	*Calamus spp.* Linn.	Palmae
Red lauan	*Shorea negrosenensis* Foxw.	Dipterocarpaceae
Rice	*Oryza sativa* Linn.	Gramineae
Santol	*Sandoricum koetjape* (Brum. f) Merr.	Meliaceae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Siniguelas	*Spondias purpurea* Linn.	Anacardiaceae
Soybean	*Glycine max* (Linn.) Merr.	Leguminosae
Squash	*Cuburbita maxima* Duchesne	Cucurbitaceae
Strawberry	*Fragaria vesca* Linn.	Rosaceae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Talinum	*Talinum triangulare* Willd.	Portulacaceae
Tamarind	*Tamarindus indica* Linn.	Leguminosae
Tanguile	*Shorea polysperma* (Blco.) Merr.	Dipterocarpaceae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae
Tugue	*Dioscorea esculenta* (Lour.) Burkill.	Dioscoreaceae
Ubi	*Dioscorea alata Linn.*	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Watermelon	*Citrullus vulgaris Schrad*	Cucurbitaceae
White lauan	*Pentacme contorta* (Vid.) Merr. & Rolfe	Dipterocarpaceae
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceae
Yam	*Dioscorea esculenta* (Lour.) Burkill.	Dioscoreaceae

BIBLIOGRAPHY

AFAGA, E. A., G. B. QUERIJERO and R. SAMANIEGO. "Chemical Characteristics of the Soils of Camarines Norte," *Soil Survey of Camarines Norte Province, Philippines.* DANR Soil Report 23. Manila: Bureau of Printing, 1965.

BROWN, W. H. *Useful Plants of the Philippines.* Department of Agriculture and Commerce Technical Bulletin 10. 3 vols. Manila: Bureau of Printing, 1941 and 1946.

Bureau of the Census and Statistics. *Census of the Philippines: 1960.* Agriculture, Vol. I, Report By Province, Isabela, 24. Manila: Bureau of the Census and Statistics, 1963.

Bureau of the Census and Statistics. *Census of the Philippines: 1960. Population and Housing,* Vol. I, Report by Province, Isabela. Manila: Bureau of the Census and Statistics, 1962.

Bureau of the Census and Statistics. "Estimated Total Area of the Philippines by Province, City, Municipality, Municipal District." Manila: Bureau of the Census and Statistics, 1963. (Mimeographed.)

Census Office of the Philippine Islands. *Census of the Philippines: 1918* Vol. I. Manila: Bureau of Printing, 1920.

DAGDAG, B. C., ET AL. *Soil Survey of Cagayan Province, Philippines.* DANR, Soil Report 36. Manila: Bureau of Printing, 1965.

DAGDAG, B. C., C. G. GALAMAY AND J. P. MAMAOG. *Soil Survey of Nueva Vizcaya Province, Philippines.* DANR, Soil Report 32. Manila: Bureau of Printing, 1963.

JACKSON, M. L., *Soil Chemical Analysis.* N. Y.: Prentice Hall, 1958.

KELLOGG, CHARLES E., *Soil Survey Manual.* U.S.D.A., Miscellaneous Publication No. 274. Washington, D.C.: Government Printing Office, 1937.

LYON, T. L. and H. O. BUCKMAN. *The Nature and Properties of Soils.* 4th ed. N.Y.: The Macmillan Co., 1947

MARFORI, R. T. and I. E. VILLANUEVA. "The Chemical Characteristics of the Soils of Ilocos Sur Province," *Philippine Journal of Soils,* (at the press).

MERRILL, ELMER *D. An Enumeration of Philippine Flowering Plants.* Bureau of Science, Publication No. 18. Manila: Bureau of Printing, 1922–1926.

PEECH, M. and L. ENGLISH. "Rapid Micro-chemical Soil Test," *Soil Science, 57:* 167–195, 1944.

PETTINGER N. A. "A Useful Chart for Teaching the Relation of Soil Reaction to the Availability of Plant Nutrients to Crops," *Bull. 136.* Va., 1935.

PIPER, C. S. *Soil and Plant Analyses.* N.Y.: Interscience, Inc., 1950.

QUERIJERO, G. B. and R. T. MARFORI. "Some Chemical Characteristics and Fertilizer Requirements of the Soils of Cebu Province," *Philippine Journal of Soils,* (at the press).

SPURWAY, C. H. "Soil Testing, a Practical System of Soil Analysis *Michigan Agricultural Experimental Station, Technical Bulletin 132.* Michigan: 1939.

TRUOG, EMIL. "The Determination of the Readily Available Phosphorus of Soils," *Jour. Amer. Soc. Agron., 22*: 874–882, 1930.

WAKSMAN, S. A. and I. J. HUTCHINGS. "The Role of Plant Constituents in the Preservation of Nitrogen in the Soil" *Soil Science, 40*: 487–497, 1935.

WALKLEY, A. and I. A. BLACK. "Determination of Organic Matter in Soils," *Soil Science, 35*: 29–38, 1934.

Weather Bureau. *Annual Climatological Review: 1954.* Manila: Weather Bureau, 1956.

Weather Bureau. "Monthly Average Rainfall and Rainy Days in the Philippines." Manila: Weather Bureau, 1956. (Mimeographed.)