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

Soil Report 23

SOIL SURVEY OF CAMARINES NORTE PROVINCE PHILIPPINES

BY

LAUREANO R. LUCAS
Chief of Party

LUDOVICO ENGLE AND FRANCISCO G. SALAZAR
Members

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SOIL SURVEY OF CAMARINES NORTE PROVINCE [1]

CONTENTS

	Page
ILLUSTRATIONS	iii
ACKNOWLEDGMENT	1
INTRODUCTION	3
SUMMARY	5
DESCRIPTION OF THE AREA	7
CLIMATE	16
AGRICULTURE	17
SOIL SURVEY METHODS AND DEFINITIONS	25
THE SOILS OF CAMARINES NORTE	27
Soils of the Plains and Valleys	28
Soils of the Hills and Mountains	33
Miscellaneous Land Types	38
MORPHOLOGY AND GENESIS OF THE SOILS OF CAMARINES NORTE	40
LAND USE, SOIL MANAGEMENT AND WATER CONTROL ON THE LAND	42
PRODUCTIVITY RATINGS OF THE SOILS OF CAMARINES NORTE	44
TEXTURAL CLASSES OF THE SOILS OF CAMARINES NORTE	45
LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF CAMARINES NORTE	48
CHEMICAL CHARACTERISTICS, FERTILIZER AND LIME REQUIREMENTS OF THE SOILS OF CAMARINES NORTE	55
GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN CAMARINES NORTE	77
BIBLIOGRAPHY	81
SOIL MAP OF CAMARINES NORTE PROVINCE (In Pocket)	

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

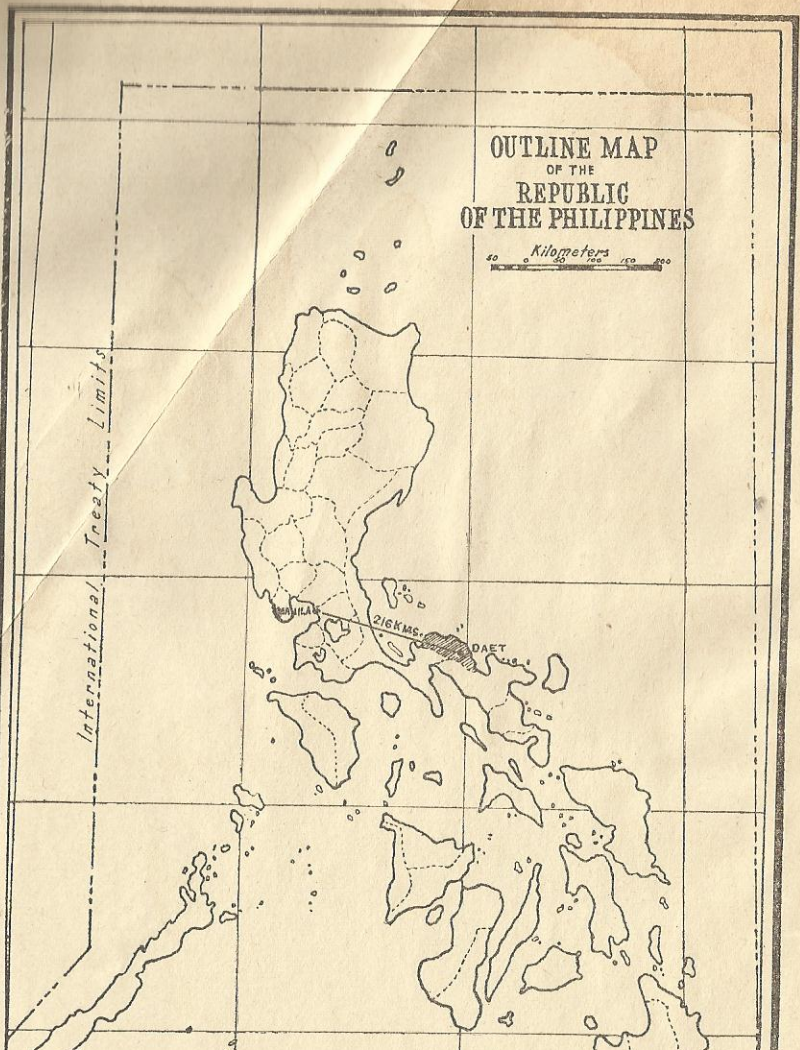

Figure 1. Outline map of the Republic of the Philippines showing the location of Camarines Norte Province.

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WITH A DISCUSSION ON THE CHEMICAL CHARACTERISTICS AND FERTILIZER AND LIME REQUIREMENTS OF THE SOILS OF CAMARINES NORTE PROVINCE

BY

EUSEBIO A. AFAGA, GLORIA B. QUERIJERO and RAMON SAMANIEGO

036469

MANILA
BUREAU OF PRINTING
1966

DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES

HON. JOSE Y. FELICIANO
Acting Secretary of Agriculture and Natural Resources

HON. ISOSCELES PASCUAL
Undersecretary for Agriculture

HON. JACINTO MONTILLA
Undersecretary for Natural Resources

BUREAU OF SOILS

ARTEMIO E. GESMUNDO
Asst. Director & Officer In-Charge

ILLUSTRATIONS

Page

FIG. 1. Outline map of the Republic of the Philippines showing the location of Camarines Norte Province .... *Frontispiece*

FIG. 2. Sketch map of Camarines Norte Province showing general topography and natural drainage system 8

FIG. 3. Processing plant of Larap Mines, Larap Peninsula, Camarines Norte 12

FIG. 4. The iron ore mines in Camarines Norte are dug as low as 800 feet below sea level 12

FIG. 5. A sawmill of the North Camarines Lumber Co., Basud, Camarines Norte 13

FIG. 6. Forest resources of Camarines Norte if properly safeguarded will continue to supply forest products indefinitely 13

FIG. 7. A typical fishing village in Camarines Norte 14

FIG. 8. A fish-drying shed in one of the coastal towns of the province 14

FIG. 9. Graph of the second type of climate of the Philippines, and of Daet, Camarines Norte 15

FIG. 10. A typical profile of Indan series 32

FIG. 11. Rice paddies on Indan clay 32

FIG. 12. A typical profile of Luisiana series 35

FIG. 13. A landscape of Luisiana series 35

FIG. 14. Chart showing general trend of relation of reaction to availability of plant nutrients 58

ACKNOWLEDGMENT

The members of the soil survey party are indebted to Governor Wilfredo Panotes and to the members of the Provincial Board of Camarines Norte for appropriating funds which defrayed part of the expense incurred in the survey and classification of the soils of the province; to the Provincial Agricultural Supervisor and his staff for the valuable information and data on agriculture in the province; and to various provincial and municipal officials who in one way or another contributed to the success of the survey.

INTRODUCTION

Our farmers till their farms generally to provide for their immediate needs and for those in the community. In most instances, therefore, the staple food is also the leading crop. However, some farmers also cultivate a crop for its commercial or dollar-earning value. Whatever the trend, it is apparent that production cannot meet demand and that average production is far below the norm.

Soil survey and classification is intended to determine the physical and chemical characteristics of soils in a given area. From these studies the needs, requirements, and capabilities of the soils studied are further determined in conjunction with farm practices, crops grown, and erosion hazards prevailing in the region.

The soils of Camarines Norte Province were surveyed and classified from September 3, 1947 to November 12, 1947, inclusive, by the Bureau of Soil Conservation (now the Bureau of Soils) under the directorship of Dr. Marcos M. Alicante and during the incumbency of Honorable Mariano Garchitorena as Secretary of Agriculture and Natural Resources.

SUMMARY

The province of Camarines Norte is the northernmost province of the Bicol Region. It has an area of about 211,249 hectares which includes those of some islands to the northeast. Daet, the provincial capital, is approximately 216 air kilometers from Manila.

Camarines Norte is largely rolling to mountainous with some narrow coastal plains and valleys floors.

The basic industries of the province are agriculture, mining, forest, and fishing. The leading crops of the province according to the 1948 census of agriculture were coconut, palay, camote, corn, cassava, abaca, sugar cane, gabi, pineapple, and peanut. In livestock and poultry Camarines Norte lags far behind other provinces. From the census figures of 1939 and 1948 farm tenure by types of farm operator in the province are cited as follows:

Types of farm operator	1939 No. of farms	1939 Total area (ha.)	1948 No. of farms	1948 Total area (ha.)
Full owners	5,134	33,804.69	6,431	41,047.37
Part owners	519	3,536.31	429	3,448.29
Tenants	4,356	24,625.08	3,177	16,251.15
Farm managers	2	134.50	....	....

The number of farms by size was as follows:

Size of farm	1939 No. of farms	1948 No. of farms
Less than 1 hectare	792	897
From 1 to less than 10 hectares	2,207	2,357
From 10 to less than 20 hectares	779	1,213
From 20 hectares and over	233	570

The population of the province increased by 72.3 per cent between 1918 and 1960. In 1918, the population was 52,081; in 1960 it was 188,091.

In the survey and classification of the soils of the province six soil types and three miscellaneous land types were delineated. There are three soil types developed from recent alluvial deposits, namely, (1) San Manuel clay loam, (2) San Manuel loam, and (3) Indan clay. These soil types have medium to coarse textures from their "A" down to their "C" horizons. Their relief is generally level to nearly level; their drainage condition ranges from good to partly excessive; their permeability is moderately rapid to very rapid. In general, San Manuel soils are productive and have excellent tilth. Indan soils, on the other hand, are generally low in fertility.

There are two soil types found in the upland areas developed from igneous rocks such as andesites and basalts, namely, (1) Alaminos clay, and (2) Luisiana clay.

These soils are fairly friable, reddish brown to red, well drained, and of moderate permeability. Their relief is usually rolling to steeply rolling. In Camarines Norte, uncultivated areas of these soils types are generally covered with dipterocarp forest or are under grass. *Kaingin* farming is prevalent in the province and usually a primary forest that was cleared by *kaingin* farmers eventually becomes a cogon covered area.

One soil type, Alimodian clay loam, is also a primary soil found on the upland areas of the province. Alimodian clay loam was developed from shale. Its relief is rolling to hilly and mountainous. This soil type is fine textured, sticky and plastic when wet, has a very slow permeability, and is generally low in fertility. Some portions are planted to upland rice, corn, root crops, and some fruit trees. The greater part of this soil type, however, is under grass while the rest is under forest.

Three miscellaneous land types, namely, (1) hydrosol, (2) mountain soils, undifferentiated, and (3) beach sand were mapped in the province. These miscellaneous land types are considered not true soils because they are not products of weathering or their horizons are not related to one another as far as soil formation is concerned.

This soil report includes tables on the productivity ratings, average mechanical analyses, land capability classification, pH requirements of some economic plants, chemical analyses of the surface soils, and the lime and fertilizer requirements of the different soil types of Camarines Norte Province.

SOIL SURVEY OF CAMARINES NORTE PROVINCE, PHILIPPINES

DESCRIPTION OF THE AREA

Location and extent.—Camarines Norte is the northernmost province of the Bicol Region. Along its northeast coast are several islands, the Calagua group, which protect the province from the northeast monsoon originating from the Pacific Ocean. To the southeast and southwest lie the provinces of Camarines Sur and Quezon, respectively. Camarines Norte has an approximate area of 2,112.49 square kilometers or 211,249 hectares.[1] Daet, the capital, is about 441 nautical miles by the shortest navigable route from Manila. By air, it is only 216 air kilometers. The Manila South Road, Highway No. 1, links this province with other provinces of Southern Luzon.

Relief and drainage.—The province is rolling to mountainous with only a small coastal plain. Situated on this coastal plain are the towns of Daet, Talisay, Vinzons (formerly Indan), Labo, and Basud. The southwestern Cordillera has a number of prominent peaks such as Mt. Labo, Mt. Cadig, Mt. Bulauan, Mt. Nalusbitan, Mt. Bayabas, Mt. Alayao, Mt. Taysan, Mt. Bagacay, and Mt. Cone. The highest peak is Mt. Labo which is about 942 meters high. This peak serves as the point of convergence of the boundaries of three provinces, namely, Camarines Norte, Camarines Sur, and Quezon. From Labo towards the west are chains of hills and rolling highlands and farther on the western part of the province consists of flat topped hills. In the vicinity of Mt. Cadig from Capalonga towards the south is a rugged rolling area which is reportedly rich in mineral deposits. Jose Panganiban (formerly Mambulao) and Paracale are the gold areas of the province. An iron mine is also located in Jose Panganiban.

Except in some portions of the lowland areas the whole province is very well drained by several rivers. The largest

[1] 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), p. 15. (Mimeographed.)

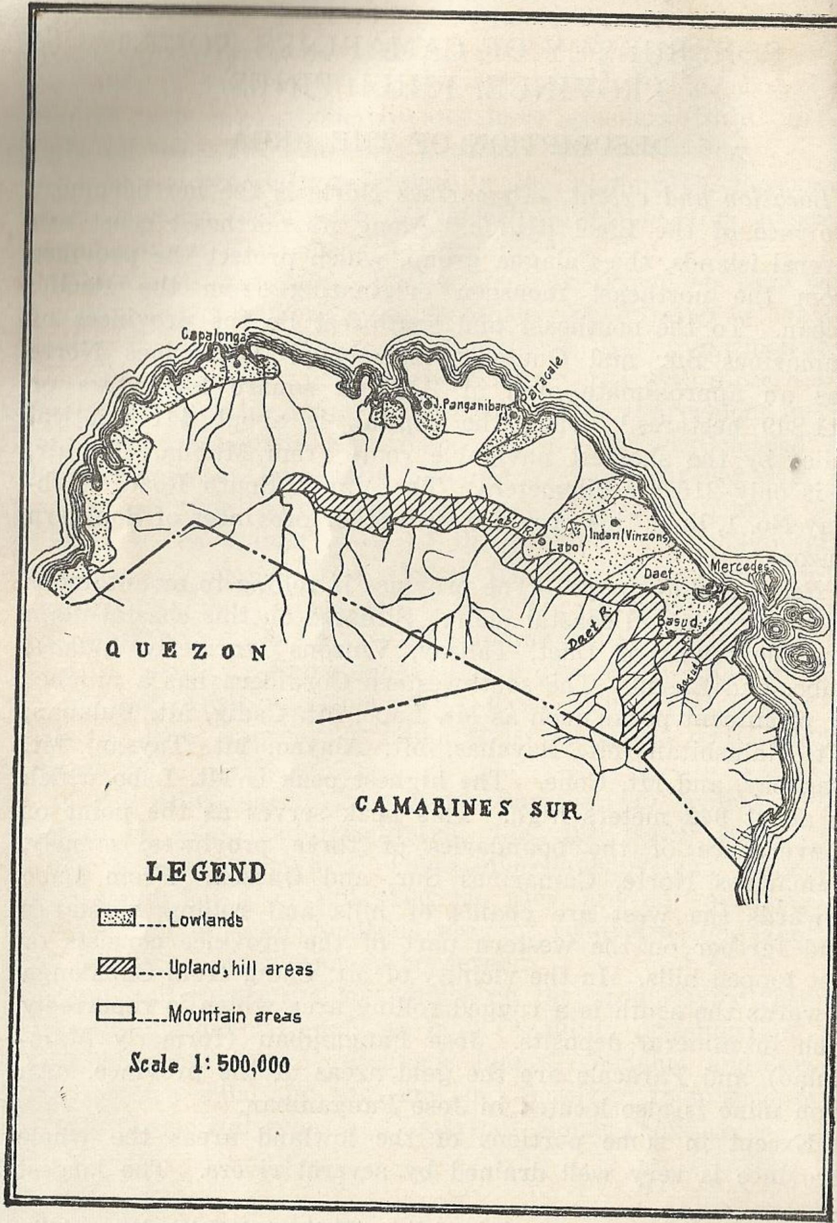

Figure 2. Sketch map of Camarines Norte Province showing general topography and natural drainage system.

rivers of the province, such as the Bosigon, Labo, Baso, and Daet Rivers, during periods of heavy rains flood and inundate the surrounding regions. Daet and Basud Rivers are navigable by launch up to about two kilometers inland. All these rivers are navigable by banca to about 15 kilometers upstream.

Vegetation.—Besides the cultivated crops like coconut, rice, abaca, root crops, corn, sugar cane, beans, and other field crops, the native vegetation of the province consists of primary and secondary forests, grasses, and mangroves and other halophytic plants. The forested areas are mostly found on the northwestern part of the province within the municipalities of Basud, San Vicente, Labo, Paracale, Jose Panganiban, and Capalonga. The open lands, abandoned *kaingin* clearings, tablelands, some hills, and rolling and undulating regions are covered with cogon, *talahib,* and other species of grasses, as well as shrubs and small trees. To some extent the abandoned *kaingin* farms and open grasslands are slowly being covered with second-growth forests. In places near the coast, especially along the mouths of big rivers, nipa palms, *bakauan,* and other halophytic plants grow luxuriantly.

Organization and population.—Camarines Norte was formerly a part of the province of Bicol, later renamed Ambos Camarines. In 1829 Camarines Norte and Camarines Sur were formed by splitting Ambos Camarines. However, in 1854 the two provinces were again merged; separated again in 1857; merged once more in 1893. On April 27, 1901, a civil government was established in Ambos Camarines. Finally, in 1919, the Philippine Legislature enacted a law providing for the division of Ambos Camarines into two provinces, namely, Camarines Norte and Camarines Sur. Under Camarines Norte were nine towns, namely, Basud, Capalonga, Daet, Indan (now Vinzons), Labo, Mambulao (now Jose Panganiban), Paracale, San Vicente, and Talisay. Some islands along its coast were also placed under the jurisdiction of Camarines Norte. Daet was made the provincial capital.

At the time of the arrival of Juan de Salcedo in the region there were several settlements already existing. The mining towns of Paracale and Mambulao were the most populated. These two towns together with Capalonga, Indan, and Labo were chiefly inhabited by Tagalogs who immigrated mostly from the town of Mauban, Tayabas Province. The other towns, although predominantly Visayan, show strong Tagalog influence. The population of the mining districts before the war was rather large but it declined during the Japanese occupation when the mines were closed.

The population of the province increased by 72.3 per cent between 1918 and 1960. In 1918, the population was 52,081; in 1960 the reported population was 188,091.

Transportation and market.—The province has a total road length of 231.70 kilometers of which 101.60 kilometers are classified first class, 92.10 kilometers second class, and 38.00 kilometers third class. Roads link all towns with the provincial capital, while the Manila South Road, Highway No. 1, connects Camarines Norte with Manila. The A.L. Amen Transportation Co. (Alatco) and the Daet Transit are the two biggest bus operators in the province.

The Philippine Air Lines, Inc. links the provincial capital with Manila and other important towns in the Bicol and Visayan provinces with regularly scheduled flights.

Ocean going steamers and inter-island vessels call at the ports of Mercedes and Jose Panganiban for cargoes of copra, abaca, lumber, and iron although boats seldom transport passengers to and from these ports.

Water supply.—Lowland areas have sufficient water supply which contains either dissolved organic matter or mineral salts, or both. Water from deep wells has a higher mineral content than that obtained from shallow wells but the bacterial count in the former is lower. Few springs exist and they occur only in stream channels and the water obtained possesses similar characteristics exhibited by water from shallow wells.

In rugged mountainous and heavily forested regions numerous streams flow through deep narrow channels. A few large streams are found in the central and western parts of the province.

Daet, Jose Panganiban, and Paracale are the only towns in the province which have water systems originating from mountain streams. The water is chlorinated and treated. All other towns depend upon artesian wells, surface wells, streams, or springs for their water supply. Some people, especially those who live along the shores, must travel several kilometers inland to obtain potable water.

Cultural development and improvements.—At present the province is composed of ten municipalities, namely, Basud, Capalonga, Daet, Jose Panganiban, Labo, Mercedes, Paracale, San Vicente, Talisay, and Vinzons. All the towns and most

of the barrios have public elementary schools. Aside from the Camarines Norte High School in Daet, there are also regional high schools in the towns of Vinzons and Paracale. There are also private high schools in Labo and a privately owned vocational college in Daet.

The Bureau of Health maintains public dispensaries in all towns. A maternity hospital, operated by the province, is located in the capital. To help the needy, such as war widows, orphans, disabled veterans, and invalids, a chapter of the Philippine National Red Cross is stationed in Daet.

Most of the people of the province are Roman Catholics. Catholic churches, many built during the Spanish regime, are found in all the towns and big barrios. Only about two per cent of the populace belong to other sects.

Industries.—Mining, forestry, and fishing, aside from agriculture, are the industries which contribute much to the income of the province. In fact, the first two industries mentioned give much more revenue to the province than any other industry including agriculture.

The mining industry of the province is mostly found in the Paracale–Jose Panganiban district, Nalusbitan district, Larap Peninsula, Pinagbarangan, and Calambayungan Island. Gold and iron are the minerals largely found in these regions. In 1938, there were 41 gold mining companies registered in Camarines Norte. Their combined total assets amounted to about ₱27,174,122.00. Iron deposits are mostly located in the Larap Peninsula, Pinagbarangan, and Calambayungan Island. The estimated total iron reserves of this industry is from 5,300,000 to 8,000,000 metric tons. There are three iron mining companies in the province with combined assets totaling ₱4,196,202.00 in 1938. During the same year the three companies had a total production of 1,760,000 metric tons of iron ore.

Logging, charcoal making, rattan gathering, firewood and tanbark gathering, and making of nipa shingles are the other industries of the province. According to the census of 1939, there were 59 establishments in the province engaged in logging or in the gathering of other forest products. Their combined gross sales amounted to about ₱1,989,158.00

Fishing, unlike mining, forest, or agriculture, is a comparatively minor industry. It is confined along the coast specially on the east coast. During the northeast monsoon, from October to April, the catch is not sufficient to meet the

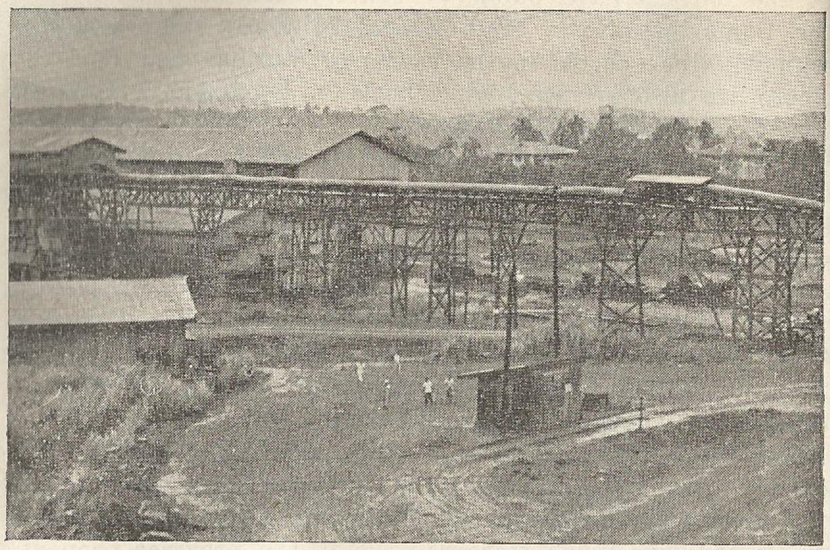

Figure 3. Processing plant of Larap Mines, Larap Penninsula, Camarines Norte.

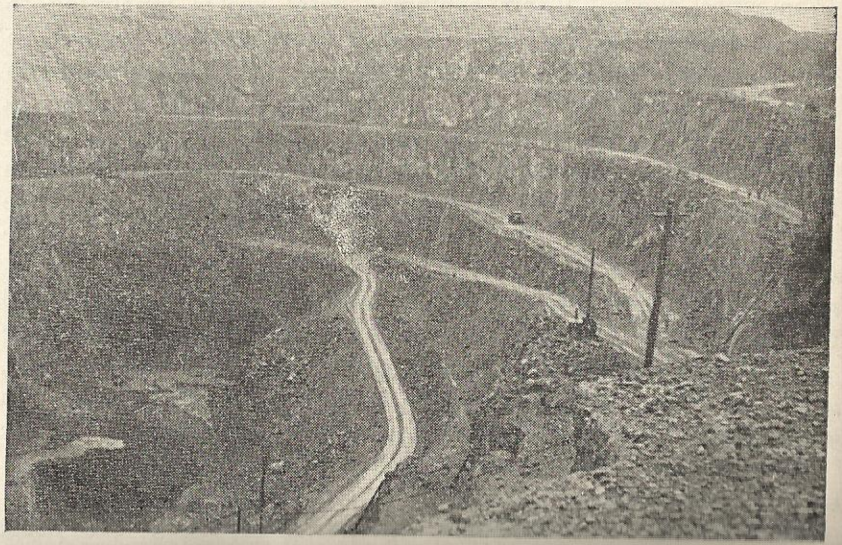

Figure 4. The iron ore mines in Camarines Norte are dug as low as 800 feet below sea level.

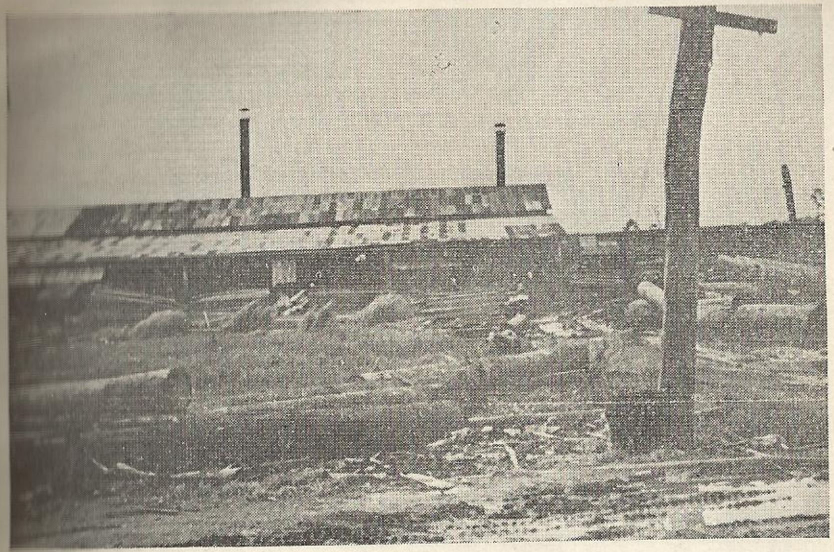

Figure 5. A sawmill of the North Camarines Lumber Co., Basud, Camarines Norte.

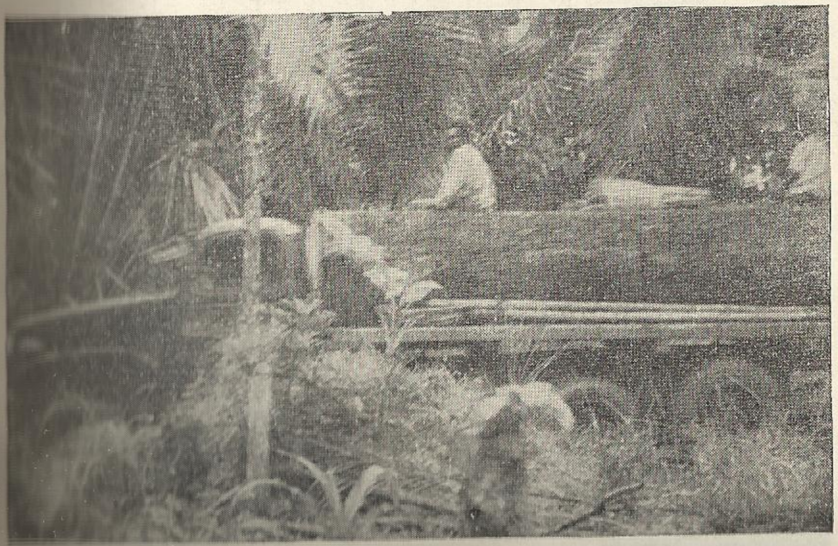

Figure 6. Forest resources of Camarines Norte if properly safeguarded will continue to supply forest products indefinitely.

Figure 7. A typical fishing village in Camarines Norte.

Figure 8. A fish drying shed in one of the coastal towns of the province.

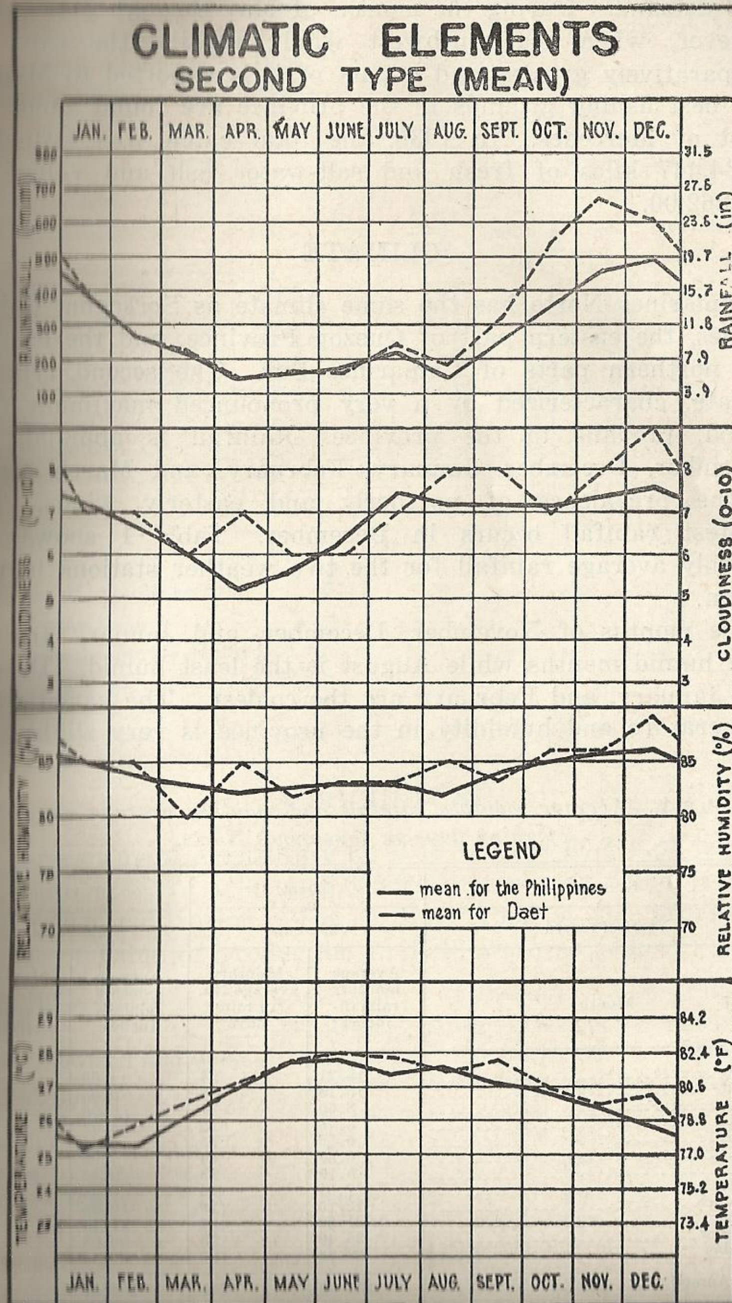

Figure 9. Graph of the second type of climate of the Philippines, and of Daet, Camarines Norte.

local demand. During the months of May through September, however, when the southwest wind prevails, the catch is comparatively greater and a part of it is exported to Manila. The best fishing grounds in the province are found along the coast of Mercedes. In 1938, the total catch was estimated at 34,447 kilos of fresh and salt-water fish and valued at ₱10,262.00.

CLIMATE

Camarines Norte has the same climate as Sorsogon, Catanduanes, the eastern part of Quezon Province, and the eastern and northern parts of Camarines Sur. The second type of climate, characterized by a very pronounced maximum rain period, prevails in the province. Rainfall is abundant in November, December, January, February, and March owing to the prevalence of northerly and easterly winds. The greatest rainfall occurs in December. Table 1 shows the monthly average rainfall for the two weather stations in this region.

The months of November, December, and January are the most humid months while August is the least humid. December, January, and February are the coldest. The variation of temperature and humidity in the province is very slight.

TABLE 1.—*Average monthly rainfall and monthly average number of rainy days in Camarines Norte.*[1]

Station	Daet		Paracale	
Years of record	29 years		29 years	
Month	Average monthly rainfall-inches	Monthly average No. of rainy days	Average monthly rainfall-inches	Monthly average No. of rainy days
January	15.21	24	14.66	20
February	10.13	18	9.05	14
March	8.60	17	6.65	14
April	5.76	12	4.37	10
May	6.58	15	6.45	13
June	6.53	14	7.06	14
July	9.19	13	9.20	16
August	7.51	16	6.34	13
September	12.10	18	10.95	15
October	21.59	24	19.14	20
November	26.40	23	20.08	25
December	23.78	22	20.46	26
Annual	153.38	221	134.41	200

[1] Weather Bureau, "Monthly Average Rainfall and Rainy Days in the Philippines" (Manila: Weather Bureau, 1956), pp. 2-8. (Mimeographed.)

TABLE 2.—*Mean, mean maximum and minimum of the monthly and annual temperatures; mean and normal relative humidity; and mean and normal cloudiness in Daet, Camarines Norte.*[1]

Station	Daet, Camarines Norte						
	Temperature—C			Relative humidity percent		Cloudiness—0-10	
1956	Mean	Mean maximum	Mean minimum	Mean	Normal	Mean	Normal 13 years
January	25.2	28.7	21.8	85	84	7	8
February	25.8	29.5	22.0	85	84	7	7
March	26.5	30.1	22.9	80	82	6	7
April	27.1	31.0	23.2	85	82	7	5
May	27.8	32.4	23.2	82	83	6	6
June	28.0	32.7	23.4	83	82	6	6
July	27.9	32.7	23.1	83	78	7	8
August	27.5	31.5	23.5	85	83	8	8
September	27.8	31.8	23.8	83	85	8	8
October	27.0	30.7	23.3	86	86	7	8
November	26.5	29.7	23.3	86	85	8	8
December	25.8	28.0	23.7	89	85	9	8
Annual	26.9	30.7	23.1	84	83	7	7

Scale of cloudiness:

0- 3—clear
4- 7—partly cloudy
8-10—cloudy or overcast

[1] Weather Bureau, Annual Climatological Review: 1956 (Manila: Weather Bureau, 1956), p. 67. (Mimeographed.)

AGRICULTURE

The census of agriculture of 1948 records 60,746.81 hectares of farm area, of which 35,628.98 hectares or 58.65 per cent are under cultivation. The leading crops of the province in terms of value of production in 1948 were as follows:

Crops	Area (ha.)	Production	Value
Coconut	16,453.58	30,382,722.0 nuts	₱2,504,441.00
Palay, lowland and upland	8,547.82	150,474.0 cavs.	1,968,315.00
Camote	1,507.83	1,776,469.0 kgs.	212,611.00
Corn (3 crops)	975.38	8,904.0 cavs.	96,645.00
Cassava	677.51	785,989.0 kgs.	87,039.00
Abaca	703.13	121,876.0 kgs.	80,098.00
Sugar cane	156.61	2,475.7 tons	69,529.00
Gabi	187.05	158,961.0 kgs.	26,933.00
Pineapple	127.61	92,381.0 fruits	13,449.00
Peanut	52.61	21,118.0 kgs.	9,582.00

CROPS

Coconut.—Coconut is the most important crop of the province, leading all other crops in area and production. With the exception of the towns of Jose Panganiban and San Vicente, all the towns of Camarines Norte cultivate no less than 1,000 hectares each of coconuts. Daet leads in coconut production. The coconut production and the value of coconut products in 1948 are listed hereunder:

Nuts and coconut products	Production	Value
Total nuts for all purposes	30,352,351 nuts	₱2,504,441.00
Coconuts for food	1,382,351 nuts	114,632.00
Sold as nuts	144,923 nuts	12,176.00
For making copra	28,392,009 nuts	2,339,776.00
For making home-made oil	463,439 nuts	77,857.00
Copra produced	7,098,004 kgs.	3,344,817.00
Home-made oil	46,339 liters	31,767.00
Tuba gathered	20,186 liters	3,661.00

Rice.—Palay is second to coconut in importance. Lowland areas near the coast particularly those in Daet, Talisay, Vinzons (formerly Indan), and Labo are intensively grown to lowland rice. Upland rice is planted on the higher, rolling, and hilly areas. Raminad, Milagrosa, Ramelon, Bulao, Ramai, Balibod, Baranay, Guinangang, Kinawayan, Pinursiguing Puti, Sinadyaya, and Dumali are the more common lowland rice varieties grown. The upland varieties are Balibod, Guinatos, Dumali, and Inintiw. Where the preparation of the land is thorough and the culture clean, the yield of lowland rice ranges from 30 to 50 cavans of palay per hectare; for the upland, from 15 to 25 cavans depending upon the fertility of the soil, preparation of the land, availability of water, and the time of planting. According to the 1948 census, the production was 150,474 cavans from 8,547.82 hectares. The value of the crop was ₱1,968,315.00. In Vinzons, Talisay, Labo, and Daet where there is sufficient irrigation water, rice is grown twice a year. The production of rice in this province is insufficient to meet local demand.

Abaca.—Abaca is one of the most important crops of the province. In spite of its suitability to the climate of the province very little has been done to promote the cultivation of this crop. After World War II many abaca plantations were either neglected or abandoned such as those in San Vicente, Paracale, Basud, and Capalonga. The area planted to this crop is steadily decreasing.

In 1938 there were 4,832.83 hectares planted to abaca as against only 703 hectares in 1948, although planters in 1948 realized more from their crops than in 1938. The value of the produce was ₱56,543.00 in 1938, and ₱80,098.00 in 1948. Daet and Labo lead in abaca production.

Root crops.—Root crops are important in Camarines Norte as substitute for rice. Root crops are grown for local consumption in the towns of Daet, Labo, and Capalonga. The most common root crops are camote, gabi, cassava, tugue, and ubi. In 1948 camote covered an area of 1,507.83 hectares; cassava, 677.41 hectares; and gabi, 187.05 hectares. The corresponding productions were 1,776,469 kilograms of camote, 785,989 kilograms of cassava, and 158,961 kilograms of gabi. The corresponding values were ₱212,611.00 for camote, ₱87,039.00 for cassava, and ₱26,933.00 for gabi.

Corn.—Corn is another staple food of the people. It is planted in rotation with other crops such as upland rice, sugar cane, root crops, and legumes. Although it serves as a secondary staple food, a comparatively very small area is utilized for its production in relation to other food crops. The total production in 1948 was 8,904 cavans of shelled corn which consisted of the first, second, and third harvests and had a total value of ₱96,645.00. That same year corn occupied 975.38 hectares. The native white and yellow flint varieties are largely grown to maturity while the white glutinous variety is generally harvested green. Usually corn is intercropped with upland rice in *kaingin* clearings. Labo produces more corn than any other town in the province. In 1939 green corn was valued at ₱523.00 which exceeded the value of the third crop of corn. In 1948 the area planted, production, and value of the three corn crops are as follows:

Corn	Area-ha.	Production-cav.	Value
First crop	777.51	7,265	₱79,788.00
Second crop	156.15	1,361	14,224.00
Third crop	41.72	278	2,633.00

Sugar cane.—Sugar cane is not produced in a commercial scale. It is either consumed locally as chewing cane or made into *panocha*. Some cane juice are also fermented into a native drink locally known as *basi*. *Panocha* making is centered in Labo. The area planted to sugar cane in 1948 was

156.61 hectares with a value of produce estimated at ₱69,529.00. The value of sugar cane grown in 1948 for different purposes are as follows:

Product	Value
Muscovado or *panocha*	₱41,032.00
Chewing purposes	25,863.00
Native wine (*basi*)	2,868.00

Other crops.—Pineapple is one of the minor crops of the province. Production of the crop was not popular in 1948 as it was in 1938. The province produced 333,348 fruits in 1938, while in 1948, the production was only 92,381 fruits. The crop is confined almost wholly along the coastal region. The fruits are consumed locally. The best markets for pineapples are in the mining towns of Paracale and Jose Panganiban.

Vegetables such as eggplants, beans, tomato, cabbage, and squash are raised in home gardens throughout the province. Truck gardening in a commercial scale is seldom found in the province in spite of the shortage of vegetables, thus, the people are forced to buy from neighboring provinces.

Fruit tree growing, although a lucrative industry in the province, has not gained much impetus. Before World War II agricultural extension agents of the Bureau of Plant Industry succeeded in convincing some farmers to plant citrus, avocado and other fruit trees. Planting, pruning, and control of insect pests and diseases were demonstrated by agricultural fieldmen of the bureau. Unfortunately, the war interrupted the work and the orchards were either abandoned or neglected. At present these orchards are being rehabilitated. Hundreds of stocks have been prepared for the purpose. In 1948, the following fruit trees, their number and value of produce were recorded:

Trees	No. of trees	Production	Value
Banana	900,363	733,215 bunches	₱739,051.00
Cacao	3,475	7,223 kilos	15,374.00
Coffee	31,610	17,653 kilos	9,512.00
Jackfruit	66,894	325,555 fruits	111,240.00
Lanzones	1,267	22,852 kilos	25,080.00
Mandarin	6.369	855,855 fruits	48,863.00
Papaya	17,849	183,203 fruits	11,958.00
Pili	7,799	259,166 kilos	53,440.00
Pummelo	11,704	273,047 fruits	16,348.00
Santol	9,124	1,689,656 fruits	9,778.00

In addition to the aforementioned crops tobacco, mungo, Irish potato, onion (big bulb), garlic, ginger grass (forage), *sincamas*, *buyo*, and maguey are also raised. Grass for pasture and forage grow in abundance throughout the province and needs but slight attention and care on the part of the farmers to provide for livestock needs.

AGRICULTURAL PRACTICES

The most common method of preparing the soil for planting is by carabao and plow. Trampling the soil by carabao alone is also practiced. Five to fifteen carabaos are used to trample the field until the soil is softened. Farming with machinery is limited to a few large farms. Maintaining or increasing the fertility of the soil by fertilization, green manuring, and crop rotation is not yet extensively observed.

Kaingin farming, in spite of its detrimental effects to the land, is still commonly practiced in the hilly areas. The open grassland and second-growth forest are cut and burned during the dry season exposing the surface soil. Clearings are abandoned after one or two seasons when the soil is no longer productive. The depletion of soil fertility resulting from accelerated erosion, and the destruction of crops and property by floods may be traced to this *kaingin* system of agriculture.

Methods of controlling soil erosion are beyond the knowledge of most farm workers. Gullying is fast destroying good farmlands. Incidentally, terracing which is used in the culture of lowland rice controls erosion. This is one of the beneficial effects of paddy culture. But in general, no effort is being done by most farmers to check and minimize erosion. Few farmers are aware that their farms are slowly becoming submarginal due to erosion as well as through poor soil management.

The agricultural extension agents in the province began their campaign on the use of selected and improved seeds and thorough preparation of the land before planting as early as the passage of Commonwealth Act 85 in 1937. Other practices to maintain the fertility of the land and to conserve the soil, such as crop rotation, green manuring, terracing, strip and contour strip cropping, fertilization, liming, and irrigation and drainage were also encouraged.

Camarines Norte is far from being self-sufficient agriculturally which may be attained by improved methods of culture, construction of irrigation facilities, proper use of the land, seed selection, etc. Although the province has a climate without a pronounced dry season, insufficiency of soil moisture during certain months causes low rice yields. Use of irrigation water to supplement rain water may well pave the way to self-sufficiency at least in rice.

LIVESTOCK AND LIVESTOCK PRODUCTS

The raising of livestock is a secondary pursuit of the people. Although not neglected, the industry has not developed to a point where it could become a major industry. There are no commercial dairy farms, poultry farms, or piggeries. In most cases fowls and swine are raised in backyards and given very little care. Pigs and chickens are loose all over the fields often destroying crops and home gardens. Most of the stock are of native breed. To improve the quality of the stock, the Bureau of Animal Industry introduced to the province foreign breeds of swine and poultry. Breeds of Duroc–Jersey and Poland China are crossed with native hogs. Boars of these breeds were distributed in the towns of Daet, Vinzons and Labo. New Hampshires and White Leghorns were introduced for the commercial production of eggs.

In this province there is an insufficient supply of beef, pork, poultry, and eggs. The recent war aggravated the situation. The census recorded the number of livestock and their corresponding value for two different years as follows:

Livestock	1939 Number	1939 Value	1945 Number	1945 Value
Carabaos	21,183	₱330,350.00	6,340	
Cattle	1,916	29,367.00	430	
Horses	239	4,093.00	160	
Hogs	18,495	113,040.00	10,240	
Goats	759	1,805.00	160	
Sheep	11	39.00	....	
Chickens	107,306		24,730	
Ducks	1,097		990	
Geese	153		30	
Turkeys	4		10	

In the above tabulation the 1945 figures are preliminary and for fowls the 1939 figures for value were not given. Likewise the corresponding values for livestock in 1945 were not cited.

There was a substantial increase in the milk produced in Camarines Norte between 1939 and 1948. In 1939, a total of 7,508 liters was produced. In 1948 the production was 84,344 liters. Other dairy products are also produced. In 1948, 26,764 liters of milk were processed into cheese. These dairy activities were conducted mostly in the homes of individual farmers.

The sources of milk produced in 1939 and in 1948 and the corresponding volume from each are enumerated hereunder:

Animals	1939 Production–liters	1948 Production–liters
Carabaos	6,712	50,102
Cows	776	32,982
Goats	20	1,260
	7,508	84,344

FARM TENURE

There are four types of farm operators in the Philippines, namely, (1) full owners, (2) part-owners, (3) tenants, and (4) managers. Tenants are further subdivided into (*a*) share tenants, (*b*) share-cash tenants, and (*c*) cash tenants. The number of farms and the total area covered correspondingly by farms classified by the type of farm operator in Camarines Norte for the two census years were as follows:

Types of farm operator	1939 No. of farms	1939 Total area (ha.)	1948 No. of farms	1948 Total area (ha.)
Full owners	5,134	33,804.69	6,431	41,047.37
Part owners	519	3,536.31	429	3,448.29
Tenants	4,356	24,625.08	3,177	16,251.15
Farm managers	2	134.50	....	....

The number of farms by size was as follows:

Size of farm	1939 No. of farms	1948 No. of farms
Less than 1 hectare	792	897
From 1 to less than 10 hectares	2,207	2,357
From 10 to less than 20 hectares	779	1,213
From 20 hectares and over	233	570

FARM INVESTMENT

In 1949, the total farm investments for 10,037 farms with an aggregate area of 60,746.81 hectares were:

Value of farm land only	₱12,370,111.00
Value of farm equipment	247,886.00

The average value of farm land per hectare was ₱204.00 while the average value of farm equipment per farm was ₱25.00.

TYPES OF FARM

Farms have been classified into 12 groups. The relationship of the area planted to a particular crop or group of crops to the total area of cultivated land in each farm constitutes the basis for classification. The first seven groups, namely, (1) palay farm, (2) corn farm, (3) abaca farm, (4) sugar cane farm, (5) coconut farm, (6) fruit farm, and (7) tobacco farm are so classified if the area planted to the specified crop is equal to 50 per cent or more of the area of cultivated land. Group 8, palay-tobacco farm, is a farm wherein the area planted to palay and tobacco are each equal to at least 25 per cent of the area of cultivated land. Group 9, vegetable farm is a farm wherein the area planted to camote, mungo, soybean, tomato, sitao, cowpeas, patani, beans, kadios, onion, radish, eggplant, cabbage, gabi, watermelon and/or potatoes is equal to 50 per cent or more of the area of the cultivated land. Group 10, livestock farm, is a farm having (*a*) an area of 10 hectares or more; (*b*) more than 10 heads of cattle, horses, goats, and sheep; and (*c*) less than 20 per cent of the total farm area used for the production of crops, fruits or nuts. Group 11, poultry farm, is a farm where there are more than 300 chickens or 200 ducks and less than two hectares of the entire area are cultivated. Group 12, other farms, are those farms which could not be classified under any of the above eleven groups.

According to the census of 1948, the number of farms, farm area and farm land classified according to use by type of farm in Camarines Norte were as follows:

Type of farm	No. of farms	Area-ha.
Palay	2,672	10,754.58
Corn	84	253.37
Abaca	110	910.81
Sugar cane	50	184.53
Coconut	4,474	33,937.64
Fruit	357	390.03
Tobacco	6	43.63
Vegetable	19	146.39
Root crop	418	1,810.72
Livestock	....	....
Poultry	....	....
Others	1,847	12,315.11

LAND USE CHANGES

Rice and other crops are mostly cultivated in the valleys and coastal plains. Some of the rolling areas, plateaus and hills are planted to coconut, banana, fruit trees, and coffee. During the Japanese occupation a great portion of idle lands, pasture, and forested areas were cultivated. After rice is harvested lowland rice fields are used for pasture. Mangrove and nipa swamps, river deltas, and protected shallow bays being developed into fishponds.

The 1948 census indicates that the province has not yet recovered fully from the effects of the war. More land was cultivated in 1939 than in 1948. While cultivated land and forest land decreased within the ten-year period, a big gain may be noted in idle land. It may be mentioned also that while population increased the area of cultivated land decreased. The extent of the different kinds of land in Camarines Norte for the years 1939 and 1948 are enumerated hereunder:

Kind of land	1939 Area (ha.)	1948 Area (ha.)
Cultivated land	38,850.00	35,628.98
Idle land	7,956.93	8,103.39
Pasture land	2,061.65	3,311.34
Forest land	11,951.86	10,838.97
Other land	1,779.24	2,864.13
	62,100.58	60,746.81

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.

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. The horizons of the profile, 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 content of lime and salts are determined either in the field or in the laboratory. The drainage, both external and internal, and other features such as the relief of the land, climate, natural and artificial features are taken into consideration, and the 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) soil complex. Areas of land that have no true soils, such as river beds, coastal beaches, or bare rocky mountain sides are called (5) miscellaneous land types. Areas that are inaccessible like mountains 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 similar parent material. It comprises of soils which have essentially the same general color, structure, consistency, range of relief, natural drainage condition and other important internal and external characteristics. In the establishment of a series, a geographic name is selected, taken usually from the locality where the soil was first identified. For example, the Indan series was first found and classified in the municipality of Indan.

A soil series has one or more soil types, defined according to the texture of the upper part of the soil, or the surface soil. The class name such as sand, loamy sand, sandy loam, silty clay loam, clay loam or clay is added to the series name to give the complete name of the soil. For example, Indan loam is a soil type within the Indan 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 soil type is a variation within the type, differing from the soil type only in some minor features, generally external, that may be of special practical significance. Differences in relief, stoniness, and extent or degrees of erosion are shown as phases. A minor differences 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 requirement 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 gravel and stone 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, in an area, there are several series such as Alimodian, Luisiana, and Alaminos 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 Alimodian or Alaminos complex.

Surface 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 types or phases. Profile samples are also obtained for further morphological studies of important soil types.

The soil survey party, composed of two or three technical 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 are indicated on the soil map, such as trails, railroads, bridges, telephones and telegraph lines; barrios, towns, and cities; rivers and lakes; prominent mountains, and many others.

THE SOILS OF CAMARINES NORTE

The soils of Camarines Norte were divided into three groups, namely, (1) soils of the plains and valleys, (2) soils of the hills and mountains, and (3) miscellaneous land types. The soil types or miscellaneous land types under each group are as follows:

Soil and Miscellaneous land types	Number
A. Soils of the Plains and Valleys	
1. San Manuel clay loam	236
2. San Manuel loam	190
3. Indan clay	528
B. Soils of the Hills and Mountains	
1. Alaminos clay	166
2. Luisiana clay	239
3. Alimodian clay loam	126
C. Miscellaneous land types	
1. Hydrosol	1
2. Mountain soils, undifferentiated	45
3. Beach sand	118

TABLE 3.—*Area in hectares and proportionate extent of each soil type or miscellaneous land type in Camarines Norte.*[1]

Soil or misc. and type number	Soil type or miscellaneous land type	Area hectares	Per cent
190	San Manuel loam	75.49	0.04
236	San Manuel clay loam	20,469.20	9.69
528	Indan clay	6,362.92	3.01
166	Alaminos clay	58,668.30	27.77
239	Luisiana clay	94,020.25	44.51
126	Alimodian clay loam	2,318.69	1.10
1	Hydrosol	2,944.20	1.39
45	Mountain soils, undifferentiated	21,418.24	10.14
118	Beach sand	1,941.23	0.92
	Unsurveyed	3,030.48	1.43
	Total	211,249.00	100.45

[1] The area of each soil or miscellaneous land type was determined by planimeter from the soil map.

SOILS OF THE PLAINS AND VALLEYS

Soils under this group are secondary soils or transported soils. These soils were formed from transported and relatively recently deposited soil materials wherein the soil transforming processes have made very little or no modifications to the original materials. The deposited soil material or alluvium is the fine material, such as sand, mud, or other sediments deposited on land by streams.

SAN MANUEL SERIES

The relief of this series is level to nearly level. The series is usually flooded during heavy rains. The surface soil is light brown to dark brown, or pale brownish gray; granular; friable and loose. The sandy loam subsoil is light grayish

brown to light gray; coarse granular; and slightly loose. The depth of the surface soil and subsoil reaches to about 70 centimeters from the surface. The substratum is light yellowish brown to light brown very fine sandy loam to sandy loam with yellowish brown mottlings.

San Manuel clay loam (236).—This soil type is found in separate places, namely, in the low plain bordering the shores of Daet, Talisay, and Indan between the mouths of the Basud and Daet Rivers; the plain bordering the rolling areas of Basud, Jose Panganiban (formerly Mambulao), San Vicente, and Labo; and a small area at the mouth of Daet River and a strip along the banks of Labo River. The places covered by this soil type are the most important agricultural areas of Camarines Norte.

The surface soil is light grayish brown, reddish brown, dark brown to dark gray clay loam. Soils nearer the sea and along the banks of the Labo River are lighter in color and in texture.

The soil is easy to cultivate. The soil has a rapid permeability, although the drainage in some places is rather poor because of their relatively low position. The soils at the mouth of the Daet River and along the banks of the Labo River which are slightly lighter in texture than in other areas are cultivated to vegetables, corn, sugar cane, watermelon, melon, and root crops. Corn and vegetables are the principal crops. The relief in these places is level to nearly level. Internal drainage is very good. Rice is also planted but the production is low, averaging only from 15 to 20 cavans of palay per hectare. During heavy rains the aforementioned places are flooded.

The area adjacent to the rolling areas of Basud, Jose Panganiban, San Vicente, and Labo are sufficiently elevated to permit adequate internal and external drainage. The relief is level to nearly level. The sandy nature of the soil permits rapid percolation. Formed from alluvial deposits originating from forested areas the soil contains a moderate amount of decayed organic materials.

The principal crops cultivated for many years are coconut and abaca. These crops are still cultivated. Corn is not widely planted and is found only on a few patches. Upland rice and sugar cane are grown in a limited scale.

The low-lying land between the mouths of the Basud and Daet Rivers is covered by soil of slightly heavier texture than in places already mentioned occupied by the San Manuel series. It is slightly compact. Upon drying it bakes and cracks. The soil in this particular place is not as easy to cultivate as the soil of the same type found in other places. Upon plowing big clods are formed. At optimum moisture content, however, the soil crumbles easily. Due to its low position, draining the land is not practicable especially during the months of heavy rainfall. Flooding during heavy rains is rather common. Rice is the principal crop. The average production is about 50 cavans of palay per hectare. Corn, sugar cane, banana, peanut, mungo, cassava, and fruit trees are grown to a limited extent. Corn is grown twice a year. The first planting is done in February or March and the crop is harvested at about the end of April to early May. The second planting is done in June or July and the crop is harvested at the end of August to early September.

San Manuel clay loam covers an aggregate area of 20,469.20 hectares or 9.69 per cent of the total land area of the province. A typical profile of the soil type found between kilometers 12 and 13 along the Labo–Talisay road is outlined hereunder:

Depth (Cm.)	Characteristics
0– 20	Surface soil, clay loam; brown to dark brown; granular; friable. Boundary with the subsoil is smooth and diffused.
20– 75	Subsoil, fine sandy loam; light brown to brown; coarse granular structure; loose. Boundary with underlying layer is smooth.
75–120	Substratum, sandy loam; light brown to yellowish brown; coarse granular structure; friable.
120 and below	Light grayish brown to grayish brown coarse sand.

San Manuel loam (190).—This soil type is located at the mouth of the Daet River east of the town of Daet and about half a kilometer south of the Daet–Mercedes road. A small strip is also found along the banks of the Labo River starting from the town of Labo and ending at the mouth of the same river.

The surface soil is about 10 to 20 centimeters deep. Some gravels and stones are present in some places. The vegetation is mostly cogon and *talahib*. During the survey the area was not cultivated but was used as a communal pasture. This soil

type covers 75.49 hectares or about 0.04 per cent of the area of the province.

INDAN SERIES

Indan series is found on some of the level areas of the province. It has a light brown to grayish brown surface soil with brown streaks. The brown streaks indicate that the soil has long been utilized for lowland rice culture. The subsoil is light grayish brown to gray, compact, and heavier in texture than the surface soil. It has reddish brown mottlings. Some highly weathered concretions are found embedded in this layer. The substratum is light gray to gray, soft gravelly clay. Five meters or more from the surface the soil is grayish brown, fine sandy loam.

Generally, the soil is cloddy, but with the right amount of moisture it crumbles easily and is easy to cultivate. Unlike San Manuel soils, the surface soil of Indan series when dry is hard and more effort is required to prepare the land. However, it is quite fertile and with good soil management and proper preparation of the land, greater yields may be expected.

Practically the whole area is planted to lowland rice except the elevated areas which are planted to coconut, sugar cane, fruit trees, root crops, and corn. The areas planted to lowland rice are the poorly drained places. Rice is grown once a year but if irrigation facilities were installed to supply water adequately rice crops may be grown twice a year.

Indan clay (528).—There are three separate places in the province where this soil type is found. The widest area lies north of the lower part of Labo River; the second is in the western part of the poblacion of Indan (now Vinzons) and extends southward to the town of Talisay; and the third lies east of the lower part of Basud River.

The clay surface soil is light brown to grayish brown with brown streaks. It is waxy and hard when dry. The average depth of the surface soil is 20 centimeters. Below this layer is grayish brown to very light gray clay loam with reddish brown mottlings. This subsoil is compact and its permeability is slow. Iron concretions are present in this layer. The average depth of the subsoil is 70 centimeters from the surface. The substratum is light gray to gray, soft gravelly clay.

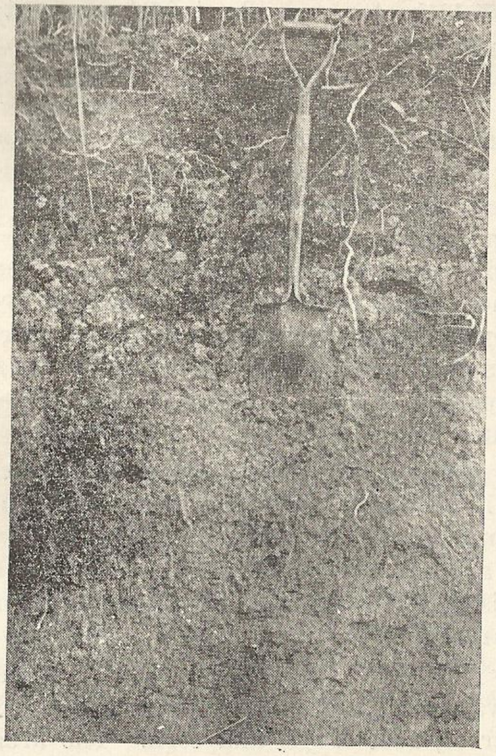

Figure 10. A typical profile of Indan series.

Figure 11. Rice paddies on Indan clay.

The lower portion of the western part of the town of Vinzons (formerly Indan) and the area north of Labo River are poorly drained. Rice is the main crop on this soil type. The average production is 35 cavans of palay per hectare. Corn, sugar cane, root crops, mungo, cowpea, coconut, and fruit trees are also grown on this soil type. Corn is planted twice a year. The coconut trees are badly attacked by *cadang-cadang*. The fruit trees grown are jackfruit, coffee, avocado, soursop, sugar apple, santol, and banana.

The elevation of this soil type is from 10 to 20 feet. Indan clay has an area of 6,362.92 hectares or 3.01 per cent of the total area of the province. A typical profile of this soil type found and examined at kilometer 3 of the Daet–Talisay road has the following characteristics:

Depth (Cm.)	Characteristics
0–25	Surface soil, clay; light brown to grayish brown with reddish brown streaks; granular structure; waxy and cracks upon drying; loose and friable when moist. Boundary with subsoil is smooth and diffused.
25–80	Subsoil, clay loam; light grayish brown to gray with reddish brown mottlings; compact; iron concretions embedded in this layer. Boundary with substratum is smooth and diffused.
80–150	Substratum, clay loam; whitish gray to gray; granular structure; soft; iron concretions present.

Soils of the Hills and Mountains

Soils under this group are known as primary soils or soils formed in place. They are developed from igneous, metamorphic, or sedimentary rocks.

ALAMINOS SERIES

Soils of this series occupy the hilly and mountainous areas of the province and are associated with soils of the Luisiana series. The Alaminos series is generally forested predominantly with dipterocarp trees. Some areas which were formerly forested but cleared by *kaingin* farmers have *parang* type of vegetation. Cultivated areas are planted to upland rice, coconut, abaca, banana, root crops, and fruit trees. The yield of upland rice is about 15 cavans of palay per hectare.

The series is characterized by light reddish brown, reddish brown to brick red soils which are loose and friable with no very definite horizon differentiation. Concretions are present in the profile. In some places cobblestones and boulders of basalt, andesite, and gabbro are found on the surface.

Alaminos clay (166).—This soil type was mapped in three different places in the province, namely, at the western tip of the province, at the northern part of the province from Capalonga to Paracale, and in the vicinities of San Vicente and Basud. The gold and iron mines in Camarines Norte are found in these areas.

The soil to a depth of 20 centimeters is light reddish brown to brick red, hard and compact clay which becomes sticky when wet. However, the soil dries easily and a few hours after an intense rain plowing is possible. The underlying layer at an average depth of 50 centimeters from the surface is clay loam, brown and compact.

Alaminos clay covers about 58,668.30 hectares or 27.77 per cent of the total area of the province. A typical profile located at kilometer 346 along the Batobalane–Jose Panganiban road is described hereunder:

Depth (Cm.)	Characteristics
0– 20	Surface soil, clay; pale reddish brown to brown; granular; friable when moist, sticky when wet. Concretions are present in this layer. Boundary with subsoil is smooth and diffused.
20– 75	Subsoil, clay loam; brown; compact; granular; friable when moist, sticky when wet. Concretions are present. Boundary with underlying layer is smooth and diffused.
75–150	Substratum, clay; yellowish brown; granular; friable. Highly weathered rock and gravels of sandstone, basalt, and andesite are embedded in this layer. Concretions are present.

LUISIANA SERIES

This series covers the largest area in Camarines Norte. It is distributed throughout the province and covers most of the hilly and mountainous regions. Most of the series is covered with forest which is predominantly of the dipterocarp type. In cleared areas coconut, banana, rice, corn, root crops, and fruit trees are grown. The yield of upland rice is from 10 to 15 cavans of palay per hectare. The cultivated areas planted to the aforementioned crops are all *kaingin* clearings.

The soil is characterized by its uniform red color throughout its profile. White splotches, especially in the lower portion of the profile, are present. The change in color is very

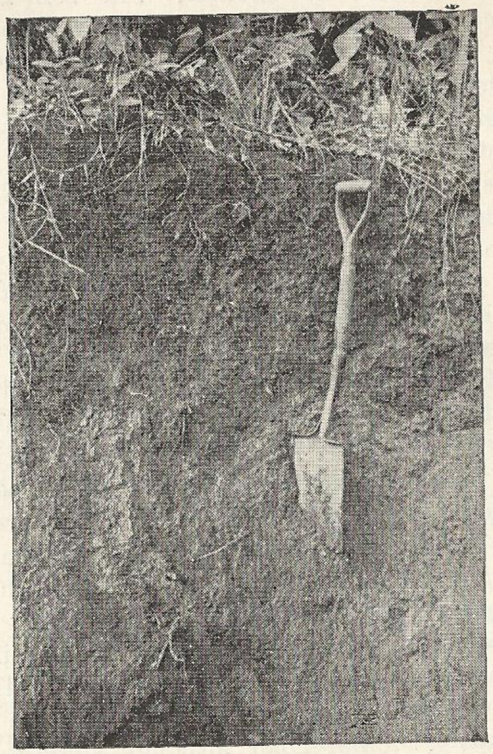

Figure 12. A typical profile of Luisiana series.

Figure 13. A landscape of Luisiana series.

slight from one layer to another. The soil is friable and granular, and although fine in texture, internal drainage is fair. When wet, the soil is sticky. To preserve the soil structure, plowing should be done when the soil is sufficiently drained to its optimum moisture content. Only a relatively small percentage of the land is suitable for the cultivation of annual crops, because most of the area is hilly with steep slopes. With the present method of farming where steep slopes are planted to seasonal crops without observing soil conservation measures this soil type is being gradually eroded. Erosion is the main cause of declining yields on this series.

Luisiana and Alaminos series belong to the red tropical group of soils. Both are developed from volcanic rocks principally basalt and andesite. They occupy a rolling to steep relief. Both are red, but while the Luisiana series is free or almost free from coarse skeletons, the Alaminos series contains iron concretions. Soils of the Luisiana series are also deeper and more uniform in color than those of the Alaminos series.

Luisiana clay (239).—This soil type is reddish brown clay, friable and granular. When wet, it is slightly sticky. The surface soil has an average depth of 25 centimeters. The subsoil is clay loam which is reddish brown with some gray splotches, a distinguishing characteristic of the series. The substratum has a similar color although slightly lighter than the overlying layers. This is due to the presence of white splotches.

Coconut, banana, rice, corn, and sugar cane are the main crops planted. Upland rice and corn are planted on *kaingin* clearings. This soil type covers 94,020.25 hectares or 44.51 per cent of the provincial total. A typical profile located at kilometer 379 along the Naga-Daet highway is described hereunder:

Depth (Cm.)	Characteristics
0– 25	Surface soil, clay; light brown to reddish brown; granular; sticky when wet, friable when moist. Highly weathered gravels are present in this layer. Boundary with the subsoil is smooth and diffused.
25– 80	Subsoil, clay loam; brown to reddish brown; compact; granular; sticky when wet, friable when moist. Boundary with substratum is diffused and smooth. Splotches of white are present in the lower portion of this layer.
80–150	Substratum, clay; brown to yellowish red; granular; sticky.

ALIMODIAN SERIES

Soils of the Alimodian series have rolling, hilly to mountainous relief. External drainage is good to excessive; internal drainage is fair. They were developed from shale and sandstone. The native vegetation consists of primary and secondary forests. Cleared areas for cultivation which were abandoned after a year or two are covered with cogon and *talahib*.

Alimodian clay loam (126).—This soil type is an extension of the same soil type found in Camarines Sur on the west coast of San Miguel Bay. The surface soil is brown to reddish brown clay loam, granular in structure, slightly friable when moist and brittle when dry. Rounded gravels and stones are sometimes present on the surface. The depth of the surface soil ranges from 20 to 40 centimeters. The subsoil is of the same texture but slightly lighter in color than that of the surface soil. It has a columnar structure, is slightly brittle when dry, plastic and sticky when wet. The substratum which begins at about 55 to 60 centimeters from the surface is gray to grayish brown highly weathered shale. This layer is slightly compact.

This soil type is often associated with Luisiana clay. Both of these soil types belong to the red group of soils, but while the soils of the Luisiana series were derived from igneous rock, Alimodian soils were derived from shale and sometimes sandstone. When the parent rock is not evident, one type may be mistaken for the other.

Patches of cleared land or *kaingin* are grown to upland rice, corn, banana, root crops, and some fruit trees.

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

Depth (Cm.)	Characteristics
0– 30	Surface soil, clay loam; brown to reddish brown; granular structure; friable when moist, hard and brittle when dry; fair organic matter content; easily penetrated by roots. Boundary with subsoil is clear and smooth.
30– 60	Subsoil, clay loam; light brown; slightly brittle, hard and compact; poor in organic matter. Boundary with substratum is clear and smooth.
60–150	Substratum, highly weathered shale or sandstone; gray to grayish brown; weak coarse platy structure; slightly compact; stratified shale or sandstone underlies this horizon.

MISCELLANEOUS LAND TYPES

Under this group are areas covered by materials which cannot be classified as true soils because they are not the products of weathering or the horizons are not related to one another as far as soil formaticn is concerned. Also included under this group are non-agricultural soils with physical characteristics or features like slope and stoniness, and with chemical compositions which do not warrant cultivation.

Hydrosol (1).—Hydrosol comprises the mangrove and nipa swamps at the mouth of rivers and along shores which are under water almost throughout the year. This miscellaneous land type is found at the mouths of the Basud, Daet, Malagnot, and Mandasco Rivers which are all in the municipality of Mercedes; at the mouths of Labo and Auitan Rivers in the municipalities of Labo and Vinzons (formerly Indan), respectively; at the mouths of Batobalane and other small rivers in the municipality of Paracale; at the mouths of Alayac and Mataqui Rivers at Alayao Bay; and at the mouth of Basiad River in the municipality of Capalonga.

Hydrosol is characterized by a brackish aqueous horizon ranging in depth of from 10 to 100 centimeters. The subaqueous horizon is a slimy, grayish clay mixed with plenty of undecomposed organic debris which is a very favorable medium for the growth of algae and other aquatic plants on which milk fish thrive. Fishponds for milk fish or *bangus* culture similar to those around Manila Bay may bring additional income to the province. The dense growth of *bakauan* and other halophytic plants are also excellent sources of firewood. The hydrosol in Camarines Norte has an area of 2,944.20 hectares or 1.39 per cent of the total area of the province.

Mountain soils, undifferentiated (45).—This miscellaneous land type occupies the mountainous areas along the Camarines Norte–Quezon–Camarines Sur provincial boundaries. It is characterized by rugged and steep slopes. The land is rough and difficult to traverse. Agriculturally, this miscellaneous land type is of little value, and is best suited to forest and wild life.

Beach sand (118).—Beach sand is found along the shores of the coastal towns of Mercedes, Daet, Talisay, Vinzons, Paracale, Jose Panganiban, and Capalonga. The native vegetation consists of *pandan*, shrubs, and runner grass. Farther

TABLE 4.—*Key to the soils of Camarines Norte and their vegetative cover.*

Soil type, misc. land type No.	Soil type or miscellaneous land type	Parent material	Relief	Drainage		Present use-Vegetation
				External	Internal	
236	San Manuel clay loam			Good	Good	Vegetables, corn, sugar cane, watermelon, melon, root crops, rice.
190	San Manuel loam	Recent alluvial deposits.	Level to nearly level			Pasture.
528	Indan clay			Poor to fair	Poor to fair	Lowland rice, sugar cane, corn, root crops; coconut; fruit trees.
166	Alaminos clay					Upland rice; coconut, abaca, banana fruit trees; root crops.
239	Luisiana clay	Igneous rocks, mostly basalt and andesite.	Rolling to hilly and mountainous.	Good to excessive.	Good	Coconut, banana, coffee, cacao, abaca, fruit trees; upland rice, corn, sugar cane; forest, cogon.
126	Alimodian clay loam	Shale			Fair	Upland rice, corn; banana, root crops, fruit trees; forest, cogon.
1	Hydrosol	Recent alluvial deposits.	Level	Poor	Poor	Mangrove, nipa palms, fish pond.
45	Mountain soils, undifferentiated		Mountainous			Primary and secondary forest; grass.
118	Beach sand		Level to nearly level	Good	Good	Coconut, root crops, banana, fruit trees.

inland where organic matter is incorporated with the sand sweet potato, cassava, breadfruit, soursop, sugar apple, banana, and coconut are grown. This miscellaneous land type covers an area of 1,941.23 hectares or 0.92 per cent of the total area of the province.

Some islands to the northeast of the province which are under the jurisdiction of Camarines Norte were not visited during the soil survey and classification in this province. This was due primarily to the lack of transportation facilities during that time.

MORPHOLOGY AND GENESIS OF THE SOILS OF CAMARINES NORTE

The physical weakening of bedrock due to moisture, temperature and chemical reactions gives rise to the formation of the so-called regolith. Regolith includes all of the unconsolidated materials above the bedrock. But this physical disintegration of bedrock is only an initial phase of soil formation. The upper part of the regolith is subjected to a relatively faster physical and chemical weathering than any other part lying underneath because this upper portion is in direct contact with the atmosphere. It is the physically and chemically weathered part of the regolith which becomes the parent material for soil. The parent material together with microorganisms and higher plant life then undergo a phenomenon known as biochemical weathering wherein the microorganisms and higher plant life decay. This addition of organic matter is an essential feature of soil formation. In other words, the physical and chemical weathering of rocks should not be mistaken as the process of soil formation itself; mostly the process of soil formation is directly or indirectly biological in nature.

At least there are five factors which largely control the kind of soil developed; namely, (1) climate, (2) living organisms, (3) nature of the parent material, (4) topography of the area, and (5) the time that the parent materials are subjected to soil formation. For instance, the regolith within any given area may vary in depth, physical condition, and chemical composition. Their geologic origin also may or may not be the same. Furthermore, the position they occupy has either been reached through deposition and transportation or by the weathering in place of the country rock. Considering also the individual as well as the cumulative influence of the

different factors exerted, the variability or heterogeneity of soils even within a small area is then accounted for.

Profile Class A.—Soils under this class were developed from recent alluvial deposits. They have medium to coarse textures from their A down to their C horizons. The relief of soils under this class is generally level or nearly level. Drainage condition ranges from good to partly excessive. Their permeability is moderately rapid to very rapid. The soil series under this class are:

SAN MANUEL SERIES; AND INDAN SERIES

San Manuel soils are some of the most productive agricultural soils. The Indan series, on the other hand, is generally low in fertility. In general, soils under this profile class are used mostly for crops requiring good drainage like sugar cane, coconut, fruit trees, and vegetables. These soils easily respond to soil conservation practices.

Profile Class D.—Under this class are soils of upland areas developed from hard igneous rocks, such as andesites and basalts. The soils thus developed are fairly friable, reddish brown or dark brown to red. The internal drainage of these soils is good while their permeability is moderate. The relief is usually rolling to steeply rolling, oftentimes ending up in mountain ranges. Indications show that most of the soils under this class are those known as "latosols," or soils of low to very low calcium content and are rather acidic. Their phosphorus content is also very low and has high rate of fixation. The undulating or rolling areas are cultivated to crops. Good crops of coffee, cacao or rubber were observed on these soils. Areas on steep slopes are partly grasslands but mostly under dipterocarp forest. On these soils, dipterocarp forest, which consists mostly of soft woods, grow rather well. The soft woods are produced on deep, friable soils, with plenty of available moisture. The soils under this class are:

ALAMINOS SERIES; AND LUISIANA SERIES

Profile Class E.—Under this class are soils of upland areas developed from shales. Their relief is rolling to hilly. The solum developed is from 15 to 60 centimeters and are of very fine texture. These soils are very sticky and plastic when wet and hardens upon drying. The permeability of these soils is very slow, thus runoff on cleared areas is very excessive. These soils are generally low in fertility. A greater part of these soils is under grass while the rest is under forest. The Alimodian series, under this profile class, is found in Camarines Norte.

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

Limited by the level areas of the province which consist of narrow coastal plains and small valley floors, farmers of Camarines Norte, aside from overworking the level areas, have to cultivate hillsides and mountainsides to carry on their agriculture. Level farms which have been under cultivation before Spanish rule are now mostly depleted of their fertility. Constant cropping to a single crop or a sequence of crops without benefit of fertilization has brought down productivity to a very low level. Even when a farm is devoted to more than one kind of crop a year, which is seldom, the sequence is not planned in such a way as to derive beneficial effects from crop rotation. Instead, a farmer plants his crop because they are the kinds which he needs most immediately. With the increase of population, farmers of the province, therefore, had no other recourse but to open new lands on the hills and mountains. Opening new lands in this case meant the *kaingin* system of agriculture whereby a family clears a forest by burning. The family cultivates the cleared area for as long as adequate needs of the family are met but as soon as the inherent fertility of the soil is exhausted the area is abandoned. Aside from deforestation, soil erosion and eventually floods, are the consequences. The consequences can better be imagined if one bears in mind that not a few families but many families resorted to *kaingin* farming for the past few decades. Lately, however, thanks to government intervention, deforestation by *kaingin* is gradually being controlled. Hill and mountain sides opened to farming are now minimized and agricultural agencies of the government are now giving support in forms of material and technical assistance.

At present the problems which beset Camarines Norte farmers are numerous and varied. While majority of these farmers are convinced that commercial fertilizer application would enhance production most of them could not afford the necessary expense. Green manuring, crop rotation, or devoting a piece of land to what it is most suited may meet the farmers' approval in principle. However, with pressing needs and economic difficulties, most farmers cannot do otherwise but

to carry on their usual practices. In many upland as well as lowland areas crude farming methods are still employed. Preparation of the land for lowland rice is done by using at least fifteen carabaos to trample the soil until it becomes soft. Thorough preparation of the land can thus never be achieved. In many places where trampling is observed, weeds outgrow the crop under cultivation.

Soil conservation measures in the upland areas are not usually observed not because of a farmer's lack of faith in the measures but more so because of the lack of necessary funds. Contour strip cropping, buffer strips, terracing and grassed waterways need additional outlay as well as the fact that a farmer should have a long-range plan to incorporate these conservation measures in his farming program. Again the farmer must decide whether to farm in the conservation way or to follow his usual methods so as to provide for his family's needs for the current crop year. In most instances the Camarines Norte farmer, specially the small land owner, decides in favor of the latter.

Fortunately, the province has many rivers and streams to afford natural drainage. Nevertheless, because of *kaingin* farming and inadequate soil conservation measures in upland areas, siltation of rivers and streams may reach a point when surface runoff shall adversely affect the natural drainage. Opening of hillside farms without benefit of soil conservation measures will consequently end in severe soil erosion. Hand in hand with deforestation which bring about floods, soil erosion is the gravest threat to the economy of the province today.

Land use, soil management, and water control on the land in Camarines Norte needs a lot of special attention not only from the side of the farmer but also from the government. Generally, existing farm practices could not give satisfactory income for labor expended nor maintain the productivity of the soil. The 66,261 hectares of open and cultivated land in the province in 1946, in order to support the needs of the people, have been worked and cropped intensively. With the ever increasing population additional forest land has been sacrificed. Instead of this, the productivity levels of existing farms in 1946 could have been improved by scientific methods of agriculture. Government agencies such as the Bureau of Plant Industry, Animal Industry, Agricultural Extension, ACCFA, Public Works, Public Highways, Forestry and Soils have contributed singly and collectively to this end. Farmers, on the other hand, are willing to shift from submarginal land to new lands or to improve the productivity of their present farms but because of economic circumstances beyond their control the well meant reforms intended for them depend much upon other factors outside the farm.

PRODUCTIVITY RATINGS OF THE SOILS OF CAMARINES NORTE

The productivity of a soil is its capability to produce a specified crop or sequence of crops under a specified system of management. In this report soil productivity rating is based on the average crop yield of a soil type in relation to national standards established, the yield being obtained without the use of fertilizer or soil amendments. Yield predictions are arrived at in two principal ways; namely, (1) through judgments based upon evidence afforded by actual yield data from sample areas of the soil mapping units, and (2) through judgments based on comparisons of the characteristics of soils and basic knowledge of plant requirements.

Table 5 indicates the productivity ratings of the soils of Camarines Norte for the major crops grown in the province. The productivity ratings were developed mainly from estimates based upon observations and interviews supplemented by a few records and census data, thus their reliability may be only considered fair. The soil productivity rating or index

TABLE 5.—*Productivity ratings of the soils of Camarines Norte.*

Soil types	Crop productivity index [1]						
	Rice		Abaca	Camote	Cassava	Coconut	Corn
	Lowland	Upland					
Alaminos clay	55	75	70	60	60	65	70
Alimodian clay loam	-------	80	-------	50	40	65	50
Beach sand	-------	-------	-------	45	40	70	-------
Indan clay	60	85	-------	60	65	65	70
Luisiana clay	-------	65	70	55	60	70	50
San Manuel clay loam	85	80	-------	60	70	80	80
San Manuel loam [2]	-------	-------	-------	-------	-------	-------	-------

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

[2] The soil type was not cultivated during the survey.

for a given crop is expressed in terms of a standard index of 100. Thus, a productivity rating of 75 for a certain crop means that a soil is about three fourths as productive relative to the national standard, or in terms of production the soil could produce 45 cavans of palay of lowland rice where the national standard is 60 cavans of palay.

Enumerated hereunder are the standard yields of some Philippine crops that are also grown in Camarines Norte:

Crop	Index 100: yield per hectare
Lowland rice	60 cavans of palay
Upland rice	20 cavans of palay
Coconut	3,750 nuts
Corn	17 cavans of shelled corn
Abaca	15 piculs
Cassava	15 tons
Camote	8 tons

TEXTURAL CLASSES OF THE SOILS OF CAMARINES NORTE

FIELD DETERMINATION OF 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 fall apart, but if squeezed when moist, a cast can be formed which will bear careful handling without breaking.

Loam.—Loam consists of 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 the 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 analyses.

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 cobbles 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 a 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.

TABLE 6.—*Average mechanical analyses of the soils of Camarines Norte.*

Soil sample number (Field)	Soil type (Field)	Sand	Silt	Clay	Total	Laboratory
CN-7	Indan clay	22.0	36.8	41.2	53.6	Clay
-8	Indan clay	20.8	34.8	44.4	60.8	Clay
-4	Alaminos clay	18.4	18.4	63.2	69.2	Clay
-19	Alaminos clay	18.4	20.4	61.2	67.2	Clay
-38	Alaminos clay	18.2	20.6	61.2	69.2	Clay
-51	Alaminos clay	14.2	28.6	57.2	67.4	Clay
-53	Alaminos clay	29.2	10.8	60.0	66.4	Clay
-42	Luisiana clay	19.6	20.8	59.6	66.0	Clay
-43	Luisiana clay	18.2	25.0	56.8	67.4	Clay
-48	Luisiana clay	6.2	21.4	72.4	80.8	Clay
-10	San Manuel clay loam	34.0	36.4	29.6	41.6	Clay loam
-22	San Manuel clay loam	33.6	30.4	36.0	50.4	Clay loam
-30	San Manuel loam	44.4	38.6	17.0	29.2	Loam
-5	Beach sand	80.4	8.6	11.0	13.2	Loamy sand

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.

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF CAMARINES NORTE

The six soil types and three miscellaneous land types found in the province are grouped into their respective land capability classes. A land capability class is a unit of classification to which a soil type belongs from the standpoint of its apparent and potential agricultural or economic capabilities. It is, therefore, a necessity for one to know the physical as well as the chemical characteristics of each soil type to enable one to judge correctly the capability of any soil type. 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 Philippines, the three major problems on soils are (1) erosion and runoff, (2) wetness and drainage, and (3) root zone and tillage limitations, such as shallowness, stoniness, droughtiness, and salinity. The aforementioned problems further divide each class into subclasses for the soil type and are indicated by "e" for erosion and runoff; "w" for wetness and drainage; and "s" for root zone and tillage limitations.

The different land capability classes are as follows:

Class A—Very good land that can be cultivated safely and extensively to crops with ordinary good farming practices.

Class B—Good land that can be cultivated safely using easily applied conservation practices.

Class C—Moderately good land that can be used regularly for cultivated crops in a good rotation but needs intensive conservation treatments.

Class D—Fairly good land that is best suited for pasture but can be cultivated to crops in a good rotation but needs intensive conservation treatments.

Class L—This land is flat but is too wet or stony and is suited for pasture or forest.

Class M—This land is steep, eroded, rough, or shallow for cultivation but is suited for grazing or forest if well managed.

Class N—This land is very steep, eroded, rough, shallow, or dry. It is good only for forest or grazing if handled with great care.

Class X—This land is level but wet most of the time and cannot be economically drained. It can be used for farm ponds or recreational purposes.

Class Y—This land is too steep, eroded, barren, and rugged, and should be reserved only for wildlife or recreation.

LAND CAPABILITY CLASS A

Soil Type: Indan clay
San Manuel clay
San Manuel loam

Deep, level, well drained easily worked soil

Class A land is nearly level. The soils are deep, dark and usually fertile or can be made fertile under good management. They are usually deep alluvial soils which vary from silty to sandy texture. Erosion is not much of a problem. Soils under this class do not need drainage or other special practices. The land is rarely flooded. It is easy to work and can be cultivated safely with ordinary good farming methods.

Class A land is suited for intensive cropping. All crops common to the area can be grown on this land. Since soils of this class have good permeability, they are better adapted for crops other than rice. When used for lowland rice, puddling the soil is usually necessary to prevent excess seepage.

Conservation farming requires such practices as liming (agricultural lime) when needed; the use of the correct kind and quantity of fertilizers; and rotation of crops, which includes a legume or a soil improving crop for sustained production.

For better efficiency in the use of lime and fertilizers, a regular practice of green manuring or the plowing under of young green plants such as any legume crop or applying any farm manure or compost is advisable. Waterways through or adjacent to this class of land should be well vegetated with adapted grass, shrubs, or trees.

LAND CAPABILITY CLASS Ce

Soil type: Alaminos clay
Luisiana clay
Alimodian clay loam

Moderately good upland that can be cultivated safely if a carefully planned combination of conservation practices is applied.

Class Ce is moderately good land suitable for cultivation provided soil conservation practices are carefully observed to prevent erosion. The soils are good, deep to moderately deep, with slopes that range from 8 to 15 per cent. This class of land is moderately to severely eroded or is subject to erosion if unprotected.

To farm this land safely terracing supported by contour farming and strip cropping is necessary. Terraces should empty into well grassed waterways or natural drainage.

After establishing the needed conservation measures, a good soil management program should be adopted. This should include a good crop rotation using a legume as a green manure crop, judicious use of lime and fertilizers, farm manure, and compost to build up the soils.

Many crops common in the area can be grown but contouring should be observed. Fruit trees should also be planted on the contour and a leguminous cover crop should be maintained to protect the soil from erosion.

Land Capability Class De

Soil type: Alaminos clay
Luisiana clay
Alimodian clay loam

Land good enough for occasional cultivation if handled with care but best suited to pasture and forest.

Class De land has slopes up to 25 per cent with moderate to severe erosion or is subject to moderate to severe erosion if left unprotected. The topsoil is generally thin with heavy, slowly permeable subsoil. It is fairly good land that can be cultivated occasionally with proper safeguards.

To farm the land a system of properly laid out terraces, with suitable outlets included in the absence of natural outlets, should be installed. Terrace outlets must have a vegetative cover preferably grass at all times. If the grass is not well established, reseeding and fertilizing is necessary.

Plowing and other farm operations must be done on the contour. Planting of row crops is not advisable. This land when used for orchards, should be planted on the contour and a good stand of leguminous cover crop should be maintained.

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

Land Capability Class Ds

Soil type: Beach sand

Land good enough for occasional cultivation if handled with care but best suited to pasture and forest.

Class Ds land is nearly level to sloping with a deep soil although the topsoil is thin and light and very rapidly permeable subsoil which is low in available moisture. Included under this class are level or nearly level lands with deep soils but because of climatic conditions not enough moisture is available for good crop growth. In which case artificial irrigation is necessary.

This class of land is also subject to some degree of soil erosion during those sporadic heavy rainfall or due to excessive supply of irrigation water.

This land is best suited to vegetables or to truck farming. Root crops will do well too if planted at such time of the year when rainfall is abundant.

Increasing the organic matter content of the soil is recommended in order to increase its water holding capacity. This can be done by the application of animal manures.

It is not likely that this soil 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

Soil type: Alaminos clay
Luisiana clay
Alimodian clay loam

Land not suited for cultivation but good for grazing or forestry if handled with great care.

Class M land is usually on steep slopes up to 40 per cent. The soil is generally shallow or highly eroded making it unfit for seasonal cultivation. Stones or gravels may be present or even numerous that they interfere with tillage operations.

The land may be used for pasture or trees with careful management. In order to grow good legumes or grass for pasture the land should be well prepared using lime and fertilizers as recommended in order to give the young plants a good start. Diversion terraces around the heads of active gullies, if any should be constructed. Gullies that are about to develop should be smoothened and sodded. Newly developed pastures should not be grazed severely. On well established pasture grazing should be well controlled and rotated. Wherever possible stock ponds should be constructed to supply water for the animals.

Where climatic conditions permit, this land can be devoted to orchards such as citrus, coffee, mango, or the like. The trees should be planted along the contours and a good cover crop to protect the soil from washing away should be provided.

As for forest purposes, native trees should be protected from fires or *kaingin* and the bare spaces planted to wood trees like *ipil-ipil*.

Land Capability Class N

Soil type: Mountain soils, undifferentiated

Very steep land, eroded, rough, with shallow soils that can be used for grazing or for forest if handled with great care.

This kind of land is not suitable for tillage except those which are needed to establish permanent vegetation for permanent pasture land or woodland. This class has a slope up to or more than 40 per cent. The land is rugged and broken by many large gullies. The soil is badly eroded or very shallow. Stones may also be very abundant making cultivation difficult or impractical.

This land has very limited use. Where grasses grow, grazing may be allowed but must be managed very carefully to prevent erosion. The pasture land will need very liberal fertilization, liming, and reseeding.

Gullied lands are best used for trees which grow well in the locality. *Ipil-ipil* is specially recommended. Where trees are already growing, they should be protected from fires or from *kaingin*.

Land Capability Class X

Soil type: Hydrosol

Land suited only for wildlife or recreation.

Land under this class is usually level or is a slightly depressed area wherein water, either sea or fresh water, stays most of the time making it unsuitable for cropland, pasture land or forest. This miscellaneous land type is called hydrosol. This land may be used for salt beds or for fish pond sites. Ordinarily, this land is covered by mangroves or nipa palms when inundated by sea water or by grasses when occassionally flooded by fresh water. When fish ponds or salt beds are made the trees or palms may be disposed off but a wide strip of these trees should be left standing along the outer borders of the shore line to protect the site from the scouring effect of waves.

For fish ponds the site should be dug to not less than a meter in depth. To produce a good growth of algae, the feed for most fishes, the water in the pond should be fertilized.

TABLE 7.—*Land capability classification of the different soil or miscellaneous land types in Camarines Norte.*

Soil type, misc. land type No.	Soil type or miscellaneous land type	Possible soil Units slope-erosion [1]	Land capability class
180	San Manuel loam		
136	San Manuel clay loam	a-0	A
138	Indan clay		Ce
166	Alaminos clay	c-1	De
139	Luisiana clay	d-1	M
136	Alimodian clay loam	d-2	X
1	Hydrosol		N
45	Mountain soils, undifferentiated		
118	Beach sand		Ds

[1] The slope-erosion units are the possible conditions that may exist for each soil type. Any other unit with an erosion class more than the one specified above will be classed under the next capability class. Thus, Alimodian clay loam with a c-3 slope-erosion class will have a land capability class N.

CHEMICAL CHARACTERISTICS, FERTILIZER AND LIME REQUIREMENTS OF THE SOILS OF CAMARINES NORTE

EUSEBIO A. AFAGA, GLORIA B. QUERIJERO AND RAMON SAMANIEGO [1]

A soil survey of Camarines Norte was conducted from September 3, 1947 to November 12, 1947, inclusive, to identify and classify the soil types of the province. Studies on the physical, biological and chemical properties of these soil types were also made in the laboratory. The laboratory examinations are important not only in the study of soil genesis and soil formation but also in the planning of an efficient soil management and in the formation of systematic cropping practices.

Productive soils are known to contain ample supply of nutrient elements particularly those which are soluble in the soil moisture. Soluble nutrient elements are readily available for plant assimilation, provided other factors exist normally. Productive soils are also characterized by the absence of harmful chemical factors.

Chemical tests show the chemical properties of soils, such as: (a) soil reaction or pH value, (b) concentrations of toxic substances, and (c) available plant nutrient elements. The chemical tests provide a better picture of the supply of plant nutrients and other water-soluble soil constituents which are directly needed or absorbed during the life span of the plant.

The plant nutrient elements in the soil are derived from different sources. Carbon, oxygen nitrogen and hydrogen come from air and water. The mineral elements are derived from the soil materials. Lime, fertilizers and organic matter furnish the soil with some of these elements including some of the trace elements. Nitrogen, phosphorus and potassium are the primary nutrients. They are usually critical in cropped soils as large amounts are either used up by plants or carried away by drainage water. These elements are the principal components of complete fertilizers. Calcium, magnesium and

[1] Soil Physicist; Senior Soil Technologist; and, Chief, Soil Research Division, respectively.

sulfur fall under the secondary elements. The first two elements, when deficient as in non-calcareous and humid soils, render the soils very acidic. Excess oxidized sulfur renders soils also acidic. The trace elements, manganese, copper, zinc, boron, iron and molybdenum, are needed by plants in minute quantities. Nevertheless, they are also essential for plant growth. The absence or deficiency of one or more of the essential nutrients in the soil often results in low crop yields and in the poor quality of crops. Relatively high concentrations of the nutrients, especially the trace elements, create unfavorable plant growth conditions in the soil.

METHODS OF CHEMICAL ANALYSIS

The methods followed for the chemical analysis of the different soil types for their chemical properties were: (*a*) Walkley and Black for organic matter[2] (*b*) "Methods of Analysis" of the Association of Official Agricultural Chemists of United States of America for total nitrogen,[3] (*c*) Truog for available phosphorus[4] (*d*) Spurway for available ammonia-nitrogen and nitrate-nitrogen[5] and (*e*) Peech and English for available potassium, calcium, magnesium, manganese and iron.[6] The soil reactions or pH values were determined with a Beckman pH meter fitted with glass electrodes.

For the chemical properties of soils the rapid chemical tests are preferred to the total analysis. Whereas total analysis reveals the true chemical composition of the soil, the analytical procedures involved are tedious, laborious and time consuming. Furthermore, the results from the latter method include some constituents of the soil not readily available or soluble in the soil moisture under ordinary cropping conditions. It was also found that these results do not correlate well with plant growth or with the response of plants to fertilizer applications. Therefore, the usefulness of total analysis for crop production is limited.

[2] H. Walkley and I. A. Black, "Determination of Organic Matter in Soils," *Soil Science* *35*:29–38, 1934.

[3] Association of Official Agricultural Chemists, *Official and Tentative Methods of Analysis* (sixth edition; Washington, D.C.: Association of Official Agricultural Chemists, 1945).

[4] Emil Truog. "The Determination of the Readily Available Phosphorus of Soils," *Jour. Amer. Soc. Agron.* *22*:847–882, 1930.

[5] C. H. Spurway. "A Practical System of Soil Diagnosis," *Mich Agr. Expt. Sta. Tech. Bull.* 132, 1939.

[6] Michael Peech and Leah English, "Rapid Micro-chemical Soil Test," Soil Science, *57*:167–196, 1944.

INTERPRETATION OF RESULTS OF CHEMICAL TESTS

Soil reaction or pH value.—Soil reaction or pH value is an important property of the soil solution. Micro-organisms and plants respond markedly to this characteristic since microbial activities and plant growth and development depend in a large degree on the chemical reaction of their environment.

The reaction of a soil solution is either acidic, neutral or alkaline. These are the three possible soil conditions which can be determined by litmus paper, nitrazine paper or pH meter. The solution is acidic if blue litmus paper turns red in this medium. Alkaline solution, on the other hand, changes red litmus paper to blue. When the color of red or blue litmus paper as the case may be is unchanged the solution is neutral. Another method is by the use of nitrazine paper which when wetted by the soil solution, a certain shade of color is produced. In turn this color is matched with a colored pH chart which indicates the pH value of the solution. The pH meter, a sensitive electrical instrument, registers directly the pH value of the solution. The pH scale ranges from 0 to 14. A solution whose pH value is 7 is neutral. Value below pH 7 mean the solutions acidic, while values above pH 7 mean alkaline. The intensity of acidity of a solution increases as its pH value decreases, while the intensity of alkalinity increases as its pH value increases.

Soil reaction affects the availability of nutrients in the soil. The behavior and availability of nutrient elements can be understood more fully by referring to Truog's version of Pettinger's Chart[7] figure 14. This chart shows the general trend of the relation of soil reaction to the availability of plant nutrient elements. The influence of reaction on the availability of each nutrient element is indicated by the width of the band. The wider the band the more favorable is the influence. The soil reaction range which is most favorable for a satisfactory supply of nutrient elements is from slight acidity to slight alkalinity. However, a satisfactory supply of the nutrients is not assured, even if the soil reaction falls within this range. So far as soil reaction is concerned, the condition is favorable for a satisfactory supply of the nutrients in available forms. The narrow bands, on the

[7] Emil Truog, "Lime in Relation to Availability of Plant Nutrients," *Soil Science*, *65*:1–7, 1948.

other hand, do not necessarily indicate that a deficiency of the nutrient element prevails. Narrower bands only indicate that the influence of soil reaction is not favorable for an abundant supply of the nutrients in available forms. A satisfactory supply of nutrient elements depends also upon other factors. Plants have different nutrient requirements. Crops with relatively lower nutrient requirements can be fully satisfied with correspondingly lower supply of nutrients.

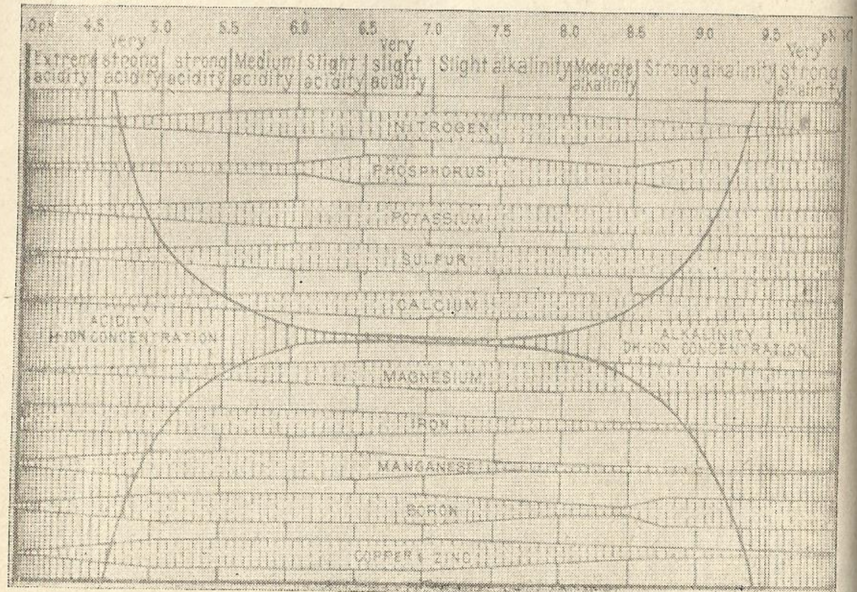

Figure 14. Chart showing general trend of relation of reaction to availability of plant nutrients.

Different crops grow normally at different soil reactions. Each plant has a specific soil reaction requirement or pH preference and different tolerance limits for its growth. The requirements of some of the economic crops are indicated in table 8.

As far as soil reaction is concerned, most of the crops indicated in table 8 can grow normally on all the soil types of the province, except on Alaminos clay. This soil type is extremely acidic for any of the economic crops. Medium acid to slightly alkaline reaction is the most favorable soil condition for crop production. The pH value of the soils of the province ranges from pH 4.10 (Alaminos clay) to pH 5.00 (Indan clay). This pH range corresponds to a reaction ranging from extreme acidity to strong acidity.

TABLE 8.—*The pH requirements of some economic plants.*

Plant	Soil reaction					
	Strongly acid pH 4.2–5.4	Medium acid pH 5.5–6.1	Slightly acid pH 6.2–6.9	Neutral reaction pH 7.0	Slightly alkaline pH 7.1–7.8	Medium alkaline pH 7.9–8.5
Abaca, *Musa textiles* Nee [1]	Y	X	X	X	Y	O
Caimito, *Chrysophyllum cainito* Linn. [1]	Y	X	X	Y	O	O
Coffee, *Coffea arabica* Linn [1]	Y	X	X	Y	O	O
Cowpea, *Vigna sinensis* (Linn.) Savi [2]	Y	Y	X	X	Y	—
Corn, *Zea mays* Linn. [1]	Y	Y	X	X	Y	Y
Durian, *Durio zibethinus* Linn. [1]	Y	X	X	Y	O	O
Peanut, *Arachis hypogaea* Linn. [2]	Y	Y	X	X	Y	—
Petsai, *Brassica pekinensis* Ruper. [4]	Y	Y	X	X	X	X
Rice, *Oryza sativa* Linn. [1]	Y	X	X	Y	Y	O
Sugar cane, *Saccharum officinarum* Linn. [2]	O	Y	X	X	X	Y
Tobacco, *Nicotiana tabacum* Linn. [2]	Y	X	Y	O	O	O
Sweet potato, *Ipomoea batatas* (Linn.) Poir. [1]	Y	X	X	Y	O	O
Cassava, *Manihot esculenta* Crantz [1]	Y	X	X	X	Y	Y
Pineapple, *Ananas comosus* (Linn.) Merr. [1]	Y	X	Y	O	O	O
Banana, *Musa sapientum* Linn. [1]	Y	X	X	X	Y	O
Tomato, *Lycopersicum esculentum* Mill [2]	Y	Y	X	X	Y	Y
Onion, *Allium cepa* Linn. [2]	O	Y	X	Y	Y	Y
Soybean, *Glycine max* (Linn.) Merr. [2]	Y	X	X	X	Y	Y
Orange, *Citrus aurentium* Linn. [3]	—	Y	X	X	X	Y

Legend:
X—most favorable reaction
Y—reaction at which plants grow fairly well or normally
O—unfavorable reaction

[1] Based from the soil reactions with the productivity ratings of the soil types in 11 provinces on which the crop is grown. A pH range of 5.7 to 6.2 was found to be the most suitable for the growth of upland rice, variety Inintiw, by Nena A. Rola and N. L. Galvez, "Effects of Soil Reaction on the Growth of Upland Rice and on Its nitrogen, Calcium, Phosphorous and Iron Content," *Philippine Agriculturist 33*: 120–125, 1949.

[2] Data taken most from Weir Wilbert Weir, *Soil Science, Its Principles and Practice*, (Chicago and Philadelphia: J. B. Lippincott, 1936).

[3] From G. H. Spurway, "Soil Reaction (pH) Preference of Plants," *Mich. Agr. Expt. Sta. Sp. Bull.* 306, 1941. Optimum range given was pH 6.0–7.5.

[4] From Antonio M. Arciaga and N. L. Galvez, "The Effect of Soil Reaction on the Growth of Petsai Plants and on Their Nitrogen, Calcium and Phosphorus Content," *Philippine Agriculturist 32*: 55–59, 1948. Normal growth reported was in pH 4.2 to 8.6: optimum range was pH 5.9–8.6.

Soil reaction varies generally from pH 3 to 10. Acid soils contain less metallic cations or exchangeable bases, such as calcium, magnesium, potassium and sodium than alkaline soils. A relationship exists between the total exchangeable bases and the total hydrogen in the exchange complex and this relationship is expressed in terms of percentage base saturation. At

80 to 90 per cent or above base saturation, the soil is neutral or alkaline. The nature of the soil micelle is another factor which influences the soil reaction. At 50 per cent base saturation, the silicate clays such as kaolinite, illite and montmorillonite may have soil reactions ranging from strong acidity to medium acidity, while those of the hydrous oxide clays lie between slight acidity to very slight acidity. Peat soils having the same base saturation are very acidic. The kinds of adsorbed exchangeable bases and their ratio in the exchange complex also affect the reaction of the soil solution. At the same percentage base saturation, soil containing higher exchangeable calcium-magnesium and lower potassium-sodium ratio or a combination of both has a lower pH value than one with higher exchangeable sodium-potassium and lower magnesium-calcium ratio or a combination of both. Carbon dioxide evolved during the decomposition of the soil materials tends to increase the degree of acidity of the soil solution. Besides this the carbonic acid formed influences the removal of the metallic bases by leaching the soluble salts of carbonates and bicarbonates, especially in regions subjected to heavy rainfall. Excess moisture hastens leaching. Leaching is also influenced by the physical properties of soils, soil management, cropping practices, climate and irrigation water. In arid regions, on the other hand, the exchangeable bases tend to accumulate at the surface. The accumulation of the salts of these bases accounts for the neutral and alkaline soil reactions. Soil treatments, physical or chemical, may change the reaction of the soil solution. Ammonium sulfate or flower of sulfur lowers the pH, while calcium carbonate, lime, calcium nitrate, or sodium nitrate, on the other hand, reverses the effect. Leaving the soil bare or any physical treatment which intensifies base removal makes soils acidic.

Organic matter.—Crop residues, farm manures and other substances of organic origin deposited on or within the soil constitute the soil organic matter. Under favorable soil conditions, the organic matter is acted upon by micro-organisms. The product of this biological process is humus. Although it is less resistant to microbial decomposition, humus is still further acted upon by the soil organisms. Through complete enzymic digestion of the organic matter, its basic chemical constituents such as carbon, hydrogen, oxygen, nitrogen, sulfur and phosphorus are liberated into the soil and into the air.

Humus is amorphous and highly colloidal. It carries a large number of negative charges similar to those of the silicate clays. Its adsorbing capacity is much higher than those of the mineral soil materials. Organic matter is also characterized as to its role in improving the soil's physical properties, namely: (*a*) water-holding capacity, (*b*) structure, (*c*) permeability, aeration and drainage, (*d*) cohesion, especially sandy soils, and (*e*) tilth. It provides home and energy for micro-organisms thereby their enzymic activities are enhanced.

The soils of the province were analyzed for their organic matter contents. The range of organic matter content in terms of percentage is from 3.48 per cent (San Manuel loam) to 5.65 per cent (San Manuel clay loam). The soils of the province and other soils in the tropics generally contain less organic matter than the soils in the humid regions. Optimum temperature and moisture content bring about microbial action which in turn influences the loss of organic matter due to its rapid transformation into its basic components.

Some soils with a relatively small amount of organic matter can be productive, but the duration of their productiveness is shorter compared to those of soils high in organic matter. Since organic matter is also a source of nutrients and releases fixed mineral elements into the soil solution, the soil fertility status is improved. Organic matter makes clayey soils friable and loose therewith plant roots can penetrate easily into the soil profile in search for food and water. Liming acid soils and fertilization of soils rich in organic matter generally give higher crop yields than when the same treatment is given to soils low in organic matter.

A sound and systematic cropping practice calls for the maintenance of organic matter content of soils in the farm. Compost and farm manures incorporated into the soil increase its organic matter content. Farm manures are allowed to rot before planting, otherwise, the excessive heat evolved during the decomposition severely injures the plant roots. Green manuring is another method of maintaining the organic material of the soils. The field is planted to leguminous crops which are then plowed under and allowed to decay. The best time for the plowing under of legumes is when they attain their maximum nitrogen content. Mungo or soybeans, for instance, attain maximum nitrogen content at their blooming stage or about 60 days after planting. Crop rotation with legume as one of the crops in the sequence is also a good farm practice, especially in fields planted to soil-depleting crops, such as rice or corn. This practice helps maintain the organic matter content of the soils.

Nitrogen, ammonia-nitrogen and nitrate-nitrogen.—The average total nitrogen of Philippine cultivated soils (surface soils) has been found to be 0.14 per cent. The supply of both ammonia and nitrates in the soil is considered low at 2 to 5 parts per million parts of soil (p.p.m.), normal or medium at 10 to 25 p.p.m. and very high or excessive at 100 p.p.m. or more. With these values for the different forms of nitrogen as bases for comparison, all the soils of the province, except San Manuel loam, have an average total nitrogen content, a normal supply of ammonia-nitrogen, and a low supply of nitrate-nitrogen. Indan clay contains a normal supply of nitrate-nitrogen and ammonia-nitrogen.

Nitrogen is an essential element needed for plant growth. Its sources are chiefly from the organic matter content of soils, applied nitrogenous fertilizers and nitrogen of the air through the nitrogen-fixing bacteria and lightning. Through enzymic digestion brought about by micro-organisms, the nitrogen of the organic matter is transformed first to ammonia, then to nitrite and finally to nitrate. These transformations are known as ammonification and nitrification. The nitrifying bacteria in moist, warm, neutral and well drained and aerated soils carry the ammonification and nitrification processes to completion or nearly so. The ammonifying bacteria are the Nitrosomonas while the nitrifying bacteria are the Nitrobacter. The ammonia-nitrogen from ammonium fertilizers undergoes similar conversion to nitrite and then to nitrate form under the same conditions. Nitrogen from the air is abundant but plants alone cannot take it up and incorporate it into the soil. The roots of legumes serve as the homes of the nitrogen-fixing bacteria which multiply rapidly and develop swellings called nodules. Through the nodules, the bacteria withdraw atmospheric nitrogen. Atmospheric nitrogen is also oxidized to its nitrate form by lightning during thunderstorms. The rain carries nitrate-nitrogen down to earth.

Plants assimilate ammonia-nitrogen and nitrate-nitrogen. Nitrate-nitrogen, being more soluble and more rapidly utilized by most crops than the ammonia-nitrogen, is easily lost from the soil through leaching and crop removal. Whatever amount

of the available forms of nitrogen remains in the soil may be reverted to the unavailable form, the elemental nitrogen. This reversion is called denitrification which takes place usually in soils which are poorly drained and not aerated. Denitrification occurs also under submerged conditions. Leaching, crop removal, denitrification and other unfavorable soil conditions influence the fluctuation of the nitrate supply of the soils during the cropping season. Nitrogenous fertilization before planting, therefore, is not an assurance for an abundant supply of available nitrogen throughout the life span of the plants. The maintenance of the organic matter in the soils and side dressing with nitrogenous commercial fertilizers may keep the soils well-supplied with these nutrients.

Nitrogen is an important constituent of chlorophyll, nucleotides, phosphatides, enzymes, protoplasm, cells, vitamins, hormones and alkaloids. These substances are found in plant tissues so that with nitrogen deficiency, plants exhibit stunted growth and the premature falling of leaves is noticeable. In addition, carbohydrate production is reduced as well as flower and fruit developments are curtailed to a large extent. These symptoms and adverse effects are also aggravated by the plant's poor assimilatory power of other nutrient elements. Poorly drained soils and soils deficient in sulfur and iron can also cause the yellowing of plant leaves. Excess nitrogen, on the other hand, cause luxurious vegetative growth but poor root system; weak and spongy tissues, hence more susceptible to lodging, pests and diseases; and delayed maturity.

The C:N ratios of the soils of the province are shown in table 9. The range is from 9:1 to 17:1.[8] San Manuel loam has a C:N ratio of 16:1, while Alaminos clay has a C:N ratio of 12:1.

The C:N ratio of arable soils (furrow soils) is about 8: to 15:1. The average is 10: to 12:1. Matured straw and green manure crops which are commonly added to the soils have C:N ratios of 80: to 90:1 and 12: to 20:1, respectively. These ratios become narrower in a relatively short time after these materials are incorporated in the soil and are acted upon by the soil organisms. A C:N ratio of 10:1 simply means that for every 10 pounds of carbon, there exists 1 pound of nitrogen.

[8] C:N ratio of 9:1 is for San Manuel clay loam and Indan clay; 17:1 for Luisiana clay and beach sand.

TABLE 9.—*Chemical analyses of the soils of Camarines Norte.*

Soil type	pH value	Organic matter per cent	Total N per cent	C:N ratio	Available constituents in parts per million (p.p.m.)							
					NH 3	NO 3	P	K	Ca	Mg	Mn	Fe
San Manuel clay loam	4.80	5.65	0.37	9:1	25	5	7	62	800	130	3	3
San Manuel loam	4.70	3.48	0.13	16:1	25	2	7	110	1100	430	46	3
Indan clay	5.00	3.60	0.23	9:1	25	10	23	96	1200	270	12	trace
Alaminos clay	4.10	3.74	0.18	12:1	25	trace	trace	177	300	90	3	1
Luisiana clay	4.20	4.43	0.15	17:1	25	2	trace	110	200	90	12	1
Beach sand	4.90	4.14	0.14	17:1	10	trace	2	82	500	100	12	trace

Plants and micro-organisms compete for the available nitrogen released from the decomposing organic matter. Carbon dioxide is evolved while nitrogen is held in the microbial tissues. Plants are starved of this nutrient until the need of the soil organisms for available nitrogen is satisfied. After their requirement is satisfied, available nitrogen begins to appear in the soil. The period of nitrogen deficiency in the soil is called the temporary nitrogen starvation period. Carbon and nitrogen are both lost or removed as decomposition of the organic matter continues. A time will come when the amount of nitrogen removed will equal the amount of carbon lost and under this condition, the constancy of C:N ratio is attained.

Phosphorus.—Although phosphorus is present both in the organic matter and in the mineral portion of soils, this element is most often deficient in agricultural soils. Considering that the total amount of phosphorus present in soils is small; that the native phosphorus, apatite, is not readily available; and, that the added phosphorus contained in soluble phosphatic fertilizers in the soil is often markedly fixed, the available phosphorus level as a result becomes quite low. The maintenance of a sufficient supply of available phosphorus by fertilization with superphosphate and the power of the soils to maintain this supply are to be considered during the cropping season. Less phosphorus fixation occurs within the soil reaction from slightly acidic to slightly alkaline.

The normal requirement for rice and other grain crops have been estimated to be about 30 to 40 p.p.m. of readily available phosphorus. This estimate was based from the data gathered from the analysis of several Philippine soils. Analyses of the soils of the province indicate phosphorus deficiency. The results obtained vary from trace (Alaminos clay and Luisiana clay) to 23 p.p.m. (Indan clay). Both San Manuel clay loam and San Manuel loam contain 7 p.p.m. of available phosphorus, while beach sand contains 2 p.p.m.

Phosphorus is also considered a growth factor, it being a plant cell component. It promotes root growth, hastens maturity of crops, and improves the quality of seeds and grains.

Plants grown on phosphorus deficient soils tend to display a general growth disturbance. Their root systems are poorly developed so that the absorbing area of the root hairs is relatively small. Besides these, the root hairs are confined to a smaller soil volume which serves as the source of plant nutrients. The consequence of an undeveloped root system and a smaller soil volume penetrated by the root hairs in search for food is the reduced power of the plants to assimilate whatever available nutrient elements present in the soil. The leaves, stems, seeds and fruits are deformed and small. The leaves and stems turn gradually from greenish-red, to reddish-brown and finally to purple. The gradual change into different shades of color is distinctly noticeable especially in corn and tomato plants. Micro-organisms are inactivated in phosphorus deficient soils so that legume plants grown on these soils suffer nitrogen deficiency.

Excess phosphorus affects some chemical activities in soils. To a slight degree, excess phosphorus causes deficiency of zinc, iron, manganese, aluminum and calcium. More iron, aluminum and manganese are tied up with phosphorus in slightly to extremely acid soils and if the supply of these trace elements is not enough to satisfy the soils' phosphorus fixing power, plants tend to exhibit iron, aluminum and manganese deficiency symptoms. Less soluble calcium phosphate may be formed in soils of higher pH levels. Excess phosphorus hastens maturity while excess phosphorus, occurring with excess nitrogen, counter-acts delayed maturity due to the excess of the latter. In the presence of a large amount of phosphorus, the potassium uptake by plants is restricted. The phosphorus content of crops is expected to be high when crops are grown on soils adequately supplied with this element. The increased phosphorus content of food crops is beneficial for man and for animals.

Potassium.—The chief sources of potassium in soils are from the mineral matter and the organic matter contents of the soils. The mineral matter contains more potassium than the organic matter. Although the total potassium content in most soils is relatively large, the amount available to plants is relatively small to support normal growth. Sandy soils as well as peat and muck soils contain lesser total potassium than the mineral clayey soils.

The availability of potassium is less influenced by the soil pH than it is for the availability of phosphorus, iron and manganese. Soils whose pH is very low usually have less available potassium while soils with higher pH or those well-limed contain larger amount of available potassium. Readily available potassium to plants is also suppressed by the potas-

sium-fixing power of the soils, especially those containing higher percentages of clay and organic matter.

Marfori, Villanueva and Samaniego investigated the fertilizer requirements for lowland rice on some Philippine soil types.[9] It was found that small applications of potassic fertilizers on highly deficient soils of available potassium, as on Buenavista silt loam and Maligaya clay loam with analyses of 9 p.p.m. and 50 p.p.m., respectively, of available potassium, did not give significant increases in crop yields. The added potassium was made unavailable by being fixed by the base exchange soil materials. Adequate potassic fertilization on these soils, however, gave significant increases in crop yields since it satisfies both the potassium-fixing power of the soil and the potassium requirement of the crop. Potassium assimilated by plants in excess of their needs is called "luxury consumption" of this element. Another experiment was also undertaken on Marikina clay loam and San Manuel silt loam containing sufficient available potassium: 132 p.p.m. and 161 p.p.m., respectively. Repeated large applications of potassic fertilizers on these soils did not give significant increases in crop yields. This means that the potassium-fixing power of these soil types and the potassium requirement of the rice plants were priorly both satisfied. In both experiments, Guinangang rice variety was used as the crop indicator. A crop indicator is a plant or a variety which is commonly grown where certain particular soil conditions prevail.

It was found that for most crops, 100 to 150 p.p.m. of available potassium in soils seem to be a sufficient supply of this nutrient element. With these findings, San Manuel clay loam, Indan clay and beach sand lack adequate supply of available potassium. Although both San Manuel loam and Luisiana clay contain 110 p.p.m. available potassium, they still require 100 to 200 kilograms of muriate of potash (60% K_2O) per hectare for crops indicated in table 10 and for some of the economic crops. Alaminos clay containing 177 p.p.m. available potassium does not require potassic fertilization.

Potassium is highly mobile in the soil water, hence it is easily leached, except when it is held by the soil colloidal complex. It is also easily lost during drainage. Potassium

[9] R. T. Marfori, I. E. Villanueva and R. Samaniego, "A Critical Study of Fertilizer Requirements of Lowland Rice on some Philippine Soil Types," *Journal Soil Science Society of the Philippines*, 2:155–172, 1950.

is also mobile in the plant sap so that potassium deficiency symptoms appear first in the older leaves. The tips and margins turn yellow and then to a brownish tint which progress towards the midrib. In extreme deficiency, the plants show stunted growth, have premature defoliation and are susceptible to pests and diseases. Likewise, the pods and seeds of legume plants are small, irregular and shrunken. In addition, the flowers, fruits, tubers and roots of crops develop abnormally. The stalks, especially of grain crops, become weak and have the tendency to lodge.

Calcium.—Calcium plays an important role in crop production. A low availability of this nutrient element may mean low crop yields, especially crops which require an adequate supply of calcium. These crops include garden and grain crops, legumes and sugar cane. Soils, especially calcareous soils, seldom lack calcium as a soluble nutrient element and its presence at a high concentration causes injury to crops that require medium to strongly acid soils.

Calcium as a liming material corrects acid soils and toxicity of other nutrients, especially the trace elements, caused by soil acidity. It increases enzymic digestion which is influenced by the presence of huge number of active soil micro-organisms. In moderately to slightly alkaline soils, the soil organisms multiply rapidly and more actively engage in the decomposition and mineralization of the soil organic matter. Calcium improves the structure of soils. Improved soil structure leads to better permeability, drainage, aeration and tillage. All these soil properties and other physical characteristics are attributed to a good supply of calcium in the soil. Calcium also acts as a binding agent for loose soils or sandy soils.

Calcium affects the behavior and availability of nutrient elements as well as the uptake of these nutrients by plants. In general, lime application is recommended to soils with pH below 5.5 for the raising of most crops. Liming strong acid soils increases the availability of the nutrient elements while adding lime to slight acid and alkaline soils increases the unavailability of phosphorus, boron, iron, manganese, copper and zinc; reduces the uptake of potassium, magnesium and boron. Liming also increases the magnesium content of soils because magnesium is often associated with agricultural lime.

Several Philippine soils were analyzed for available calcium. The soil types which were rated high in productivity gave about 2,000 to 6,000 p.p.m. of available calcium on the average.

The results of the analyses of the different soil types show that the soils of the province require more lime. Their pH values are quite low and their available calcium contents are far below the normal or average. The analyses show a range of 200 p.p.m. of available calcium (Luisiana clay) to 1,200 p.p.m. (Indan clay). Soils sufficient in calcium are suited for most crops, especially sugar cane, legumes and other high lime-demanding crops. Soils markedly deficient in available calcium usually have low productivity ratings.

Calcium deficiency symptoms appear first in young leaves and root tips of plants. Unlike potassium, calcium is much less mobile in the plant sap so that the supply of available calcium for the young leaves and root tips is inadequate. In consequence the leaves are chlorotic, irregularly curled and scorched.

Magnesium.—Magnesium is one of the essential elements for plant growth. It is present in the chlorophyll molecude, the green coloring substance of plants. In soils deficient in magnesium the plants fail to fully develop chlorophyll. Their leaves become lighter hued and then turns brownish or become spotted. In severe magnesium deficiency, the leaves, flowers and fruits prematurely fall.

In certain regions, soils which are very deficient in calcium usually have low magnesium content. Calcareous mineral soils or organic soils containing adequate calcic materials influence the low uptake of magnesium by plants. Heavy potassic fertilization may produce the same effect. Under any of these soil conditions, plants may exhibit magnesium deficiency symptoms.

Philippine soil types rated high in productivity were analyzed for available magnesium. The results ranged from 600 to 1,700 p.p.m. of available magnesium on the average. However, for certain species of citrus [pummelo or *Citrus maxima* (Brun.) Merr.], magnesium deficiency symptoms develop when soils only have 950 p.p.m. of available magnesium.

The available magnesium contents of the soils of the province are rather low. The range is from 90 p.p.m. (Alaminos clay and Luisiana clay) to 430 p.p.m. (San Manuel loam). Fertilizing them with either dolomitic limestone or magnesium sulfate may correct their magnesium deficiency.

Manganese.—Agricultural soils are generally low in their total manganese content, less than 0.1 per cent or 1,000 p.p.m.

However, the requirement for most crops is so small that it is usually satisfied.

Manganese is also essential in the formation of chlorophyll in plants. It takes part in the synthesis of proteins and vitamin C. Manganese is also a mobile nutrient element in the plant sap and the deficiency symptoms, therefore, appear first in the older leaves. The leaves are chlorotic, while the veins remain green and the areas between veins undergo color changes from green to light green and finally to brownish-red. High concentration of manganese in soils is injurious to plants. Their roots are injured and their growth are stunted.

The manganese availability to plants is also influenced by soil reaction. It is markedly available in acid soils, being more soluble in this medium than in alkaline soils, but above pH 6.5, its availability decreases. However, its deficiency may be also observed in acid clay soils, especially if its supply is small. Deficiency of available manganese may be found also in sandy soils at lower pH values. Available manganese in acid soils may be tied up with the soil complex material making it not readily available to plants. Shickluna and Davis showed that by increasing the pH of organic soils from 4.1 to 5.6, the manganese content of onion crops decreased from 1125 p.p.m. to 44 p.p.m. In another instance peat soil was limed to increase the pH from 4.9 to 7.0, the manganese content of onion tops dropped from 875 p.p.m. to 25 p.p.m.[10] These experiments revealed that the availability of manganese decreases at higher pH values.

Soil samples representing various Philippine soil types which were rated high or at least medium in crop productivity were analyzed for available manganese. The range found was from 15 to 250 p.p.m. The soils of this province were found to contain available manganese varying from 3 p.p.m. (San Manuel clay loam and Alaminos clay) to 46 p.p.m. (San Manuel loam). San Manuel loam contains a good supply of manganese while the rest of the soil types are manganese deficient, especially San Manuel clay loam and Alaminos clay.

Iron.—The analyses of average agricultural soils show as high as 5 per cent (50,000 p.p.m.) or more total iron. However, the amount of iron available to plants is very small but is usually sufficient to satisfy the needs of most crops.

[10] J. C. Shickluna and J. F. Davis, "The Chemical Characteristics and Effect of Calcium Carbonate on the Manganese Status of Five Organic Soils," *Mich. Agr. Expt. Sta. Quart. Bull.* 34:308-319, 1952.

Several soil types from various places in Luzon which were rated high in productivity were analyzed for available iron. The range found was from 2 p.p.m. to 30 p.p.m. The soils of this province were analyzed for available iron. The results were low, especially for Indan clay, Alaminos clay, Luisiana clay and beach sand.

Iron plays the role of a catalyst in photosynthesis and in other chemical reactions taking place in the plant. It is not a constituent of chlorophyll. However, it aids in its formation. Plants are chlorotic if they are deficient in iron. The leaves turn pale yellow or whitish in color. The mobility of iron through the plant sap is slow so that its deficiency symptoms also appear first on the younger leaves.

Iron deficiency may be exhibited by crops grown on soils with pH ranging from 5.5 to 8.5 because it is within this range that the low solubility of iron occurs. In strongly alkaline soils high in exchangeable sodium severe iron deficiency symptoms appear. Nevertheless, mineral soils with adequate supply of organic matter and organic soils usually contain enough iron because humus-iron combination maintains iron availability.

FERTILIZER AND LIME REQUIREMENTS

One of the measures of good soil management is the use of fertilizers and lime. "Fertilizers" include all materials that are added to the soil to increase the growth, yield, quality or nutritive value of crops. They affect the soil and plant growth in a number of ways. Their primary use, however, is to increase the supply of available plant nutrients in the soil. Fertilizers also balance the plant-nutrient ratio or in other words, they supplement the fertility of the soil.

Fertilizers and fertilizer mixtures are preferred to as containing nitrogen (N), phosphoric acid (P_2O_5) and potash (K_2O) instead of nitrogen (N), phosphorus (P) and potassium (K). These elements are combined with other elements to form either organic or inorganic compounds. Commercial fertilizers are classified as nitrogenous, phosphatic and potassic fertilizers depending on what nutrient element is contained in them. These chemical fertilizers especially the complete mixtures contain high and balanced nutrient elements which are readily available for immediate plant needs.

Nitrogenous fertilizers have their nitrogen either in the ammonium or nitrate forms. The ammonium forms are ammonium sulfate, ammonium phosphate and urea. Potassium nitrate and sodium nitrate represent the nitrate form.

Phosphatic fertilizers are either water soluble or water insoluble. Those that are water soluble are the superphosphates and the ammonium phosphates. Ordinary, double and triple superphosphates have their phosphates in the monocalcium forms which are very highly soluble in water. Ordinary superphosphate also contains calcium sulfate thereby supplying the soil with calcium and sulfur in adequate quantities for plant nutrition. Double and triple superphosphates contain a negligible amount of sulfur but they have a sufficient amount of calcium to meet the calcium demands of most crops. These ordinary and double superphosphates are non-acid forming. The water insoluble compounds are the rock phosphates, basic slag and guano. They are used preferably in acid soils where they are soluble. Rock phosphate and basic slag are alkaline in reaction and when used with acid soils they correct the unfavorable acidity of such soils.

Muriate of potash and potassium sulfate are potassic fertilizers. Muriate of potash contains 60 per cent potash (K_2O) and 50 per cent sulfate of potash. Both of these salts are highly water soluble and acid forming.

The fertilizer and lime requirements of the different soil types of Camarines Norte for lowland rice, upland rice, corn, abaca, coconut and citrus are shown in table 10.

Rice grows best on medium acid soils (pH 5.5 to 6.1) and its pH tolerance limit is estimated at pH 4.8 to 6.9. Based on this, there are only two soil types in the province which can be recommended for rice, not taking into account the beach sand. These two soil types are San Manuel clay loam and Indan clay. Alaminos clay and Luisiana clay are too acidic for rice. Since Alaminos clay and Luisiana clay contain fairly high total nitrogen and available ammonia and nitrates, nitrogen application is not required anymore. However, since both are low in available phosphorus and medium in available potassium, they require applications of phosphoric and potassic fertilizers. For upland rice, the lime requirements for the recommended soil types are twice as much as those for lowland rice.

Corn can tolerate a rather wide pH range (pH 4.8 to 8.15) although its growth is observed to be at its best at a pH range of 6.2 to 7.0. In order to raise the pH value and the calcium contents of the four soil types recommended for corn, lime application should range from 4.00 to 9.00 tons depending on their respective calcium contents. Only Indan clay does not require the application of a nitrogenous fertilizer. All of the recommended soil types require phosphoric fertilizers since their phosphorus contents are very low (trace to 7 p.p.m.). Indan clay contains a fair amount of available phosphorus. Alaminos clay which contains 177 p.p.m. of available potassium does not require any application of potassic fertilizer.

For abaca, the same soil types recommended for corn require one-half the recommended amount of lime, the same amounts of ammonium sulfate and superphosphate as shown in table 10. For muriate of potash the rate is twice that of upland rice.

TABLE 10. *Fertilizer and lime requirements of soils of Camarines Norte.*

Soil type	Agricultural lime [a] Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Muriate o potash (60% K_2O Kg./Ha.
	For lowland rice			
San Manuel loam	3.00	-----------	300	
Indan clay	2.00	-----------	100	
	For upland rice			
San Manuel loam	6.00	-----------	300	200
Indan clay	4.00	-----------	100	100
	For corn			
San Manuel loam	6.00	100	300	250
Indan clay	4.00	-----------	100	150
Alaminos clay	8.50	100	350	-----------
Luisiana clay	9.00	100	350	150
	For abaca			
San Manuel loam	3.00	100	300	400
Indan clay	2.00	-----------	100	200
Alaminos clay	4.25	100	350	-----------
Luisiana clay	4.50	100	350	200
	For coconut			
San Manuel loam	3.00	100	300	200
Indan clay	2.00	-----------	100	100
Alaminos clay	4.25	100	350	-----------
Luisiana clay	4.50	100	350	100
Beach sand	3.75	300	350	105

[a] Limestone ($CaCO_3$) pulverized to 20 mesh, 50 per cent of which must pass through 100 mesh.

For coconut, the same amounts of lime, ammonium sulfate and superphosphate for the four soil types recommended for abaca are required accordingly. In addition to these, the amount of muriate of potash should be twice as much as those recommended for abaca.

For citrus, different amounts of lime and fertilizers are required at different ages of the trees. One to three year old trees require smaller amounts than the four to six year olds and also for those over six years. In addition to lime and fertilizers, magnesium carbonate (25 per cent Mg) and manganese ore (40 per cent Mn) are recommended for application. Magnesium has been found to improve the flavor of the fruit and to increase its total soluble solids, sugar and vitamin C content.[11] The lack of a normal intake of magnesium by the plant causes a reduction in its total yield and in the size and quality of its fruits. Furthermore, the fruits easily break down in storage, their exterior have a coarser appearance and they are less fully colored externally and internally. With these findings, the application of magnesium compounds is therefore deemed necessary so as to increase the level of magnesium available to the plants.

The soils of Camarines Norte are acidic and it could be expected that manganese if present would be available. However, their analyses showed that the soils of Camarines Norte still lack manganese for the maintenance of a good crop of citrus. Manganese compounds like manganese ore (40 per cent Mn) must therefore be supplemented if the manganese contents of these soils are to be raised to adequate amounts. The importance of manganese on the growth and yields of citrus trees must not be overlooked. When present in limited amounts in soils on which citrus are grown, the young citrus leaves show a network of dark green veins over a lighter green background. In extreme cases of deficiency, yields may be considerably reduced.

The effectivity of the various fertilizers mentioned above are determined largely by the time and method of their application. When applied at the right time and in the proper manner, they stimulate the growth of the crops and produce satisfactory returns.

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[11] L. D. Batchelor and H. J. Webber (editors), *The Citrus Industry. Production of the Crop*, Vol. II. (Berkley and Los Angeles, California: University of California Press, 1948).

There are various methods of fertilizer application depending upon the nature of the crop and the conditions obtaining in the plantation. In applying fertilizers, two things must always be kept in mind: firstly, the necessity for uniform distribution and secondly, the necessity for thoroughly incorporating the fertilizer into the soil. These conditions are essential to the success of subsequent manuring. The reason is obvious, for, where the fertilizer is unevenly distributed, some areas receive abundant plant food while others receive less or possibly none at all. There must be an even distribution of fertilizers to assure each plant with sufficient food and to prevent undue waste of manures and fertilizers.

It is equally important that there must be a thorough working in of the fertilizer to insure that the plant food it contains is placed at a depth whereat it can be reached by the roots and made available to the crop. Moreover, fertilizers improve the physical conditions and the water-holding capacity of the soil. One method of distributing fertilizers evenly is by broadcasting the fertilizer over the surface of the field and subsequently working the soil with a hoe, harrow or plough. Broadcasting may be done by hand or by fertilizer distributing machines.

Fertilizers, when intended for permanent crops, are applied to a comparatively small area around the plants—usually within the area shaded by the crown. The development of an extensive root system is, therefore, encouraged. An extensive root system enables the plant to avail itself more fully of the plant food and moisture in the soil and also to resist drought better.

Another essential factor in effective fertilization is the time of application. For most crops there are certain general rules as to the right time in applying fertilizers.

For annual crops, potash should be broadcast and worked into the soil some time before planting. In this manner the potash would already be dissolved in the soil to be readily available when required by the crop.

Superphosphate may be applied to the soil just before planting is done where the soil is light or medium textured. The less soluble forms of phosphate should be applied a few weeks before planting or sowing in order that they are rendered soluble and readily assimilable by the time they will be required by the growing plants.

Nitrogenous fertilizers especially the nitrates are applied during the growth of the cultivated crops as a top dressing. In irrigated areas the application should be done before the watering of the field. When applying fertilizers like ammonium sulfate and nitrate of soda, while the plant leaves are wet the fertilizer must not fall on the leaves otherwise the fertilizer is apt to "burn" them. The less soluble nitrogenous manure must be applied some weeks before planting to provide an ample time for nitrification to take place. In this way the nitrogen would be in a readily available form when needed by the plants. Better results will be obtained from fertilizers if they are applied annually or even twice a year, rather than in larger applications at longer intervals.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN CAMARINES NORTE

Common name	Scientific name	Family
Abaca	*Musa textilis* Nee	Musaceae
Acacia	*Samanea saman* (Jacq.) Merr.	Leguminosae
Aguiñgay	*Rottboellia exaltata* Linn.	Gramineae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Akle	*Albizzia acle* Merr.	Laguminosae
Alibangbang	*Bauhinia malabarica* Rozb.	Leguminosae
Alim	*Melanolepis multiglandulosa* (Reinw) Reichb. f. and Soll.	Euphorbiaceae
Almon	*Shorea almon* Foxw.	Dipterocarpaceae
Alugbate	*Basella rubra* Linn.	Basellaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Amugis	*Koordersiodendron pinnatum* Merr.	Anacardiaceae
Anabiong	*Trema orientalis* Blume	Ulmaceae
Anahaw	*Livistonia rotundifolia* (Lam.) Mart.	Palmae
Anonang	*Cordia dichotoma* Forst	Boraginaceae
Api-api	*Avicennia officinalis* Linn.	Verbenaceae
Apitong	*Dipterocarpus grandiflorus* Blco	Dipterocarpaceae
Arrowroot	*Maranta arundinacea* Linn.	Marantaceae
Atis	*Anona squamosa* Linn.	Anonaceae
Avocado	*Persea americana* Mill.	Laureaceae
Bakauan	*Rhizophora mucronata* Linn.	Rhizophoraceae
Balete	*Ficus benjamina* Linn.	Moraceae
Balimbing	*Averrhoa carambola* Linn.	Oxalidaceae
Bamboo	*Mambusa spinosa* Roxb.	Gramineae
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lytgraceae
Banana	*Musa sapientum* Linn.	Musaceae
Banate	*Mallotus philippinensis* (Linn.) Muell.—Arg.	Euphorbiaceae
Bangkal	*Nauclea orientalis* Linn.	Rubiaceae
Batao	*Dolichos lablab* Linn.	Leguminosae
Binayoyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae
Binunga	*Macaranga tanarius* (Linn.) Muell. —Arg.	Euphorbiaceae
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineae
Buri	*Corypha elata* Roxb.	Palmae
Cabbage	*Brassica oleracea* Linn. Var. *capitata* Linn.	Cruciferae
Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae

Common name	Scientific name	Family
Calopogonium	*Calopogonium muconoides* Desv.	Leguminosae
Camansi	*Artocarpus camansi* Blanco	Moraceae
Corn	*Zea mays* Linn.	Gramineae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Cassava	*Manihot esculenta* Crantz	Euphorbiaceae
Chico	*Achras zapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea spp.* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Cowpea	*Vigna sinensis* (Linn.) Savi	Leguminosae
Cotton	*Gossypium hirsutum* Linn.	Malvaceae
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceae
Dao	*Dracontomelum dao* Merr. and Rolfe	Anacardiaceae
Dapdap	*Ertyhrina variagata* Linn. Stickm. Herb. Amb.	Leguminosae
Derris	*Derris elliptica* (Roxb.) Benth.	Leguminosae
Dita	*Alstonia scholaris* R. Br.	Apocynaceae
Dungon-late	*Heritiera littoralis* Dry	Dilleniaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculenta* (Linn.) Schott.	Araceae
Garlic	*Allium sativum* Linn.	Liliaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Guava	*Psidium guajava* Linn.	Myrtaceae
Guayabano	*Anona muricata* Linn.	Anonaceae
Himbabao	*Allaeanthus luzonicus* (Blanco) F. Vill.	Anacardiaceae
Ipil	*Intsia bijuga* O. Ktze	Leguminosae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae
Ilang-ilang	*Cananga odorata* (Linn.) Hocker f. and Thoms.	Anonaceae
Kakauate	*Gliricidia sepium* (Jacq.) Steud.	Leguminosae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Kamias	*Averrhoa balimbi* Linn.	Oxiladaceae
Katurai	*Sesbania grandiflora* (Linn.) Pers.	Leguminosae
Kondol	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae
Kudzu	*Pueraria javanica* Benth.	Leguminosae
Lañgarai	*Bruguiera parviflora* (Roxb.) W. and A.	Rhizophoraceae
Lauan	*Anisoptera thurifera* (Blanco) Blume	Dipterocarpaceae
Lettuce	*Lactuca sativa* Linn.	Compositae
Lumbang	*Aleuritis moluccana* (Linn.) Willd.	Euphorbiaceae
Makopa	*Syzygium samaragense* (Blume) Merr. and Perry	Myrtaceae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Mungo	*Phaseolus aureus* Roxb.	Leguminosae

Common name	Scientific name	Family
Mustard	*Brassica integrifolia* (West) Schulz	Cruciferae
Nangka	*Artocarpus heterophyllus* Lam	Moraceae
Narra	*Pterocarpus spp.*	Leguminosae
Niog-niogan	*Heterospathe elata* Scheff.	Palmae
Nipa	*Nypa fructicans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Orange	*Citrus aurantium* Linn.	Rutaceae
Pandakaki	*Tabaernamontana pandacaqui* Poir.	Apocynaceae
Pandan	*Pandanus tectorius* Sol.	Pandanaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Patani	*Phaseolus lunatus* Linn.	Leguminosae
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pummelo	*Citrus maxima* (Brum.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferae
Rattan	*Calamus spp.* Linn.	Palmae
Rice	*Oryza sativa* Linn.	Gramineae
Rimas	*Artocarpus communis* Forst.	Moraceae
Santol	*Sandoricum koetjape* (Brum. f) Merr.	Meliaceae
Sampaloc	*Tamarindus indica* Linn.	Leguminosae
Seguidilla	*Psophocarpus tetragonolobus* (Linn.) D.C. Prodr.	Leguminosae
Serali	*Flocourtia rukan* Zoll. and Moir	Flocourtiaceae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Squash	*Cucurbita maxima* Duchesne	Cucurbitaceae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Sweet potato	*Ipomoea batatas* (Linn.) Poir.	Convolvulaceae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Talisay	*Terminalia catapa* Linn.	Combretaceae
Tambo	*Phragmites vulgaris* (Linn.) Trin.	Gramineae
Tañgile	*Shorea polysperma* Merr.	Dipterocarpaceae
Tibig	*Ficus nota* (Blanco) Merr.	Moraceae
Tindalo	*Pahudia chomboidea* Prain	Leguminosae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Watermelon	*Citrullus vulgaris* Schrad	Cucurbitaceae
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceae

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