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

Soil Report 39

SOIL SURVEY OF ILOCOS NORTE PROVINCE PHILIPPINES

Reconnaissance Soil Survey and Soil Erosion Survey

BY

ARTURO P. MANLOÑGAT
Chief of Party

SOTERO A. CALAUSTRO AND FLORENCIO R. FRANCIA
Members

MANILA
BUREAU OF PRINTING
1968

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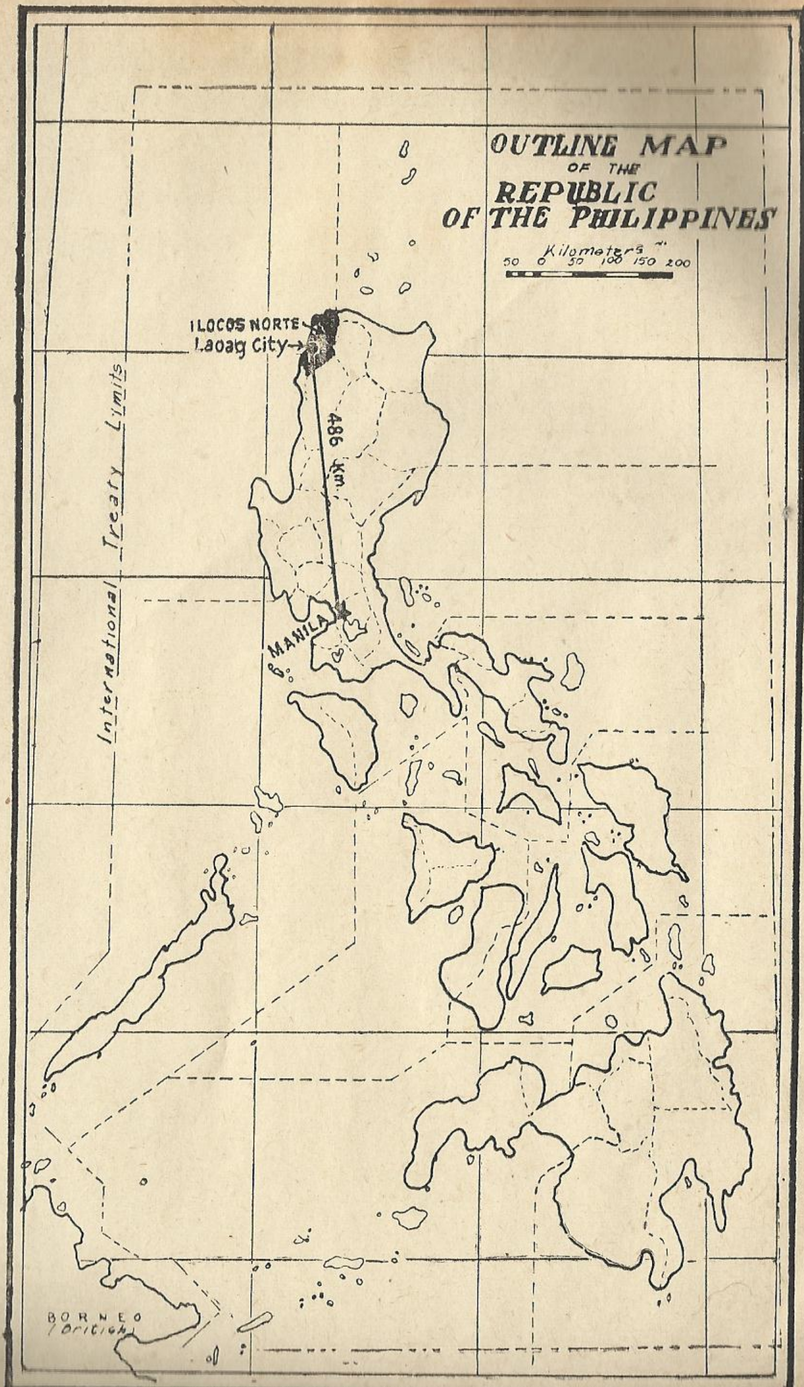

Fig. 1 Outline map of the Republic of the Philippines showing the location of Ilocos Norte Province.

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

BY

IGNACIO E. VILLANUEVA

MANILA
BUREAU OF PRINTING
1968

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INTRODUCTION

The Philippines is basically an agricultural country. As such majority of her people depend principally on agriculture for their livelihood. However, our production is so low that with the fast increasing population it is imperative that production should relatively be increased. Since production depends largely on the nature of the soil, focus of attention among farmers lies in its proper utilization and management. Before plans for proper soil management could be laid out for a sound agriculture, a soil classification survey embracing the study of the physical as well as the chemical characteristics of the soil must be conducted.

The soil report will be of much help to the people of Ilocos Norte in the attainment of sustained production and for future reference on scientific soils work elsewhere in the country.

The soils of Ilocos Norte Province were surveyed and classified in 1952 by Messrs. Isidoro A. Romero, Atanacio Simon and Baldomero Dagdag of the Bureau of Soil Conservation (now the Bureau of Soils) under the directorship of Dr. Marcos M. Alicante and during the incumbency of Honorable Juan de G. Rodriguez as Secretary of Agriculture and Natural Resources. However, Mr. Isidoro A. Romero, chief of the survey party, passed away before the soil report could be submitted. A reclassification survey of the soils of the province therefore, was conducted from March 13 to May 5, 1963, inclusive, by Messrs. Arturo P. Manloñgat, Sotero A. Calaustro and Florencio R. Francia of the same Bureau under the directorship of Dr. Ricardo T. Marfori and during the incumbency of Honorable Benjamin M. Gozon as Secretary of Agriculture and Natural Resources.

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SUMMARY

Ilocos Norte Province lies on the northwestern corner of Luzon Island. It covers a total area of 3,399.34 square kilometers or 339,934 hectares. Laoag, the capital of the province, is 486 kilometers by road from Manila.

The general relief is rolling to hilly and mountainous with scattered plains and valleys of varying sizes. The biggest valley is found in the municipalities of Banna, Marcos, Dingras, Solsona and Piddig. The eastern portion of the province is mountainous and the most prominent peaks are Mt. Linao, 1475 feet; Mt. Quiling, 1539 feet; Mt. Dinawanang, 1652 feet; Mt. Burnay, 2115 feet; and, Mt. Sicapoo, 2360 feet above sea level.

The Laoag, Bacarra, Baruyen Rivers and their tributaries drain the province towards the China Sea.

Water supply is inadequate. The only town with a water system is Laoag. The rest of the municipalities depend on pump wells and native dug wells for their water supply.

The natural vegetation is composed of commercial trees, the most common of which are white lauan, guijo, apitong, tanguile, palosapis, and molave. Grasses occupy the open land. The cultivated crops are rice, corn, tobacco, sugar cane, onion, garlic, vegetables, and root crops.

The province was created by royal decree in 1818 with 13 municipalities and a population of 135,748 people. The population of the province as of the 1960 census figures was 287,333 inhabitants.

Like the other provinces of the country, Ilocos Norte participated in the revolution that overthrew the Spanish Government in the latter part of the nineteenth century. Civil government was established in 1901. At present the province has twenty municipalities and three municipal districts.

Except for the interior towns and municipal districts, transportation in the province is adequate. As of 1962, the province has a total of 697.594 kilometers of surfaced roads of which 299.880 kilometers are first class; 216.189 kilometers, second class; and, 181.525 kilometers, third class.

There are adequate schools—elementary, high school and college levels, in the province. As of 1962 there were 459 public elementary schools, 23 private and 9 public high schools and 4

private and 1 public colleges. Aside from these there are several vocational schools located in the more progressive towns. The Bureau of Health and the Bureau of Hospitals take care of the health of the populace.

Farming is the major industry of the people. Weaving (textile and mat), salt making, fishing, and pottery are some of the important industries of the province.

The province falls under the first type of climate in the Philippines characterized by two pronounced seasons, wet and dry. The rainy season usually begins in May and ends in October.

Of the 339,934 hectares total area of the province, 45,443.7 hectares are utilized as farm lands. Rice, tobacco, garlic, corn, sugar cane, mongo, eggplant, coconut, peanut, and maguey are the ten leading crops in the province. Bananas are planted on sloping areas.

The soils of the province are classified into three general groups, namely: (1) soils of the plains and valleys; (2) soils of the upland, hills and mountains; and, (3) miscellaneous land types. There are 23 soil types under the first group; 10 soil types under the second group; and, 5 land types under the third group.

The stabilized portion of the dune land is utilized for the growing of sugar cane, cassava, and sweet potato. San Manuel soils are the most extensive of the soils of the plains. Although Cervantes soils occupy the widest area, Bolinao soils can be considered the most important soils of the upland, hills and mountains since these soils are primarily devoted to rice, tobacco, and coconut.

The productivity ratings, land capability classes, erosion classes and lime and fertilizer recommendations are included in this report.

A soil map showing the distribution of the different soil and miscellaneous land types in the province accompanies this report.

I. RECONNAISSANCE SOIL SURVEY

DESCRIPTION OF THE AREA

Location and extent.—Ilocos Norte, one of the largest provinces of the Ilocos Region is located on the northwestern corner of Luzon. It has a total land area of 3,399.34 square kilometers or 339,934 hectares. The province is composed of the mainland and one small isle, Badoc Island. It is bounded on the north and west by the China Sea, on the east by the province of Cagayan and the Mountain Province and on the south by the provinces of Ilocos Sur and Abra. Laoag, the capital of the province, is about 486 kilometers by road north of Manila. It can be reached either by plane or bus. It is linked to Manila by a first class road following the coastal line of the Ilocos Region.

The province has several ports offering protection to sailing vessels from strong winds and typhoons coming from the north. The three most important ports are located in Bangui; Diriqui, Pasuquin; and, Gaang, Currimao, the last named port being maintained by the province for its good harbor.

Relief and drainage.—The province is generally hilly and mountainous, but there are also some plains on the western part. The chain of mountains and hills traversing the province lengthwise is part of the Cordillera and Caraballo Mountains which separate the province of Ilocos Norte from the provinces of Cagayan, Abra, and Mountain Province. The most prominent peaks found in the province are Mt. Linao, 1475 feet; Mt. Quilang, 1539 feet; Mt. Dinawanang, 1652 feet; Mt. Burnay, 2115 feet; and, the highest of them, Mt. Sicapoo, 2360 feet above sea level.

With the exception of the many scattered level to nearly level lands occurring as pockets or small plains along the national highway toward the Cagayan Valley, the province has a rugged terrain. The central portion towards the east is cut by gullies and narrow ravines which are almost 500 feet deep. The upland descends abruptly in rough escarpment fringing the strips of lowlands along the Batac-Banna road, Banna-Pinili road and Piddig-Carazi road. The strips of lowlands are intersected by creeks and rivers. The province has some swift rivers but some of them dry up during the summer. During the rainy season these rivers receive the excess water coming from the mountains and hills as well as from the level areas.

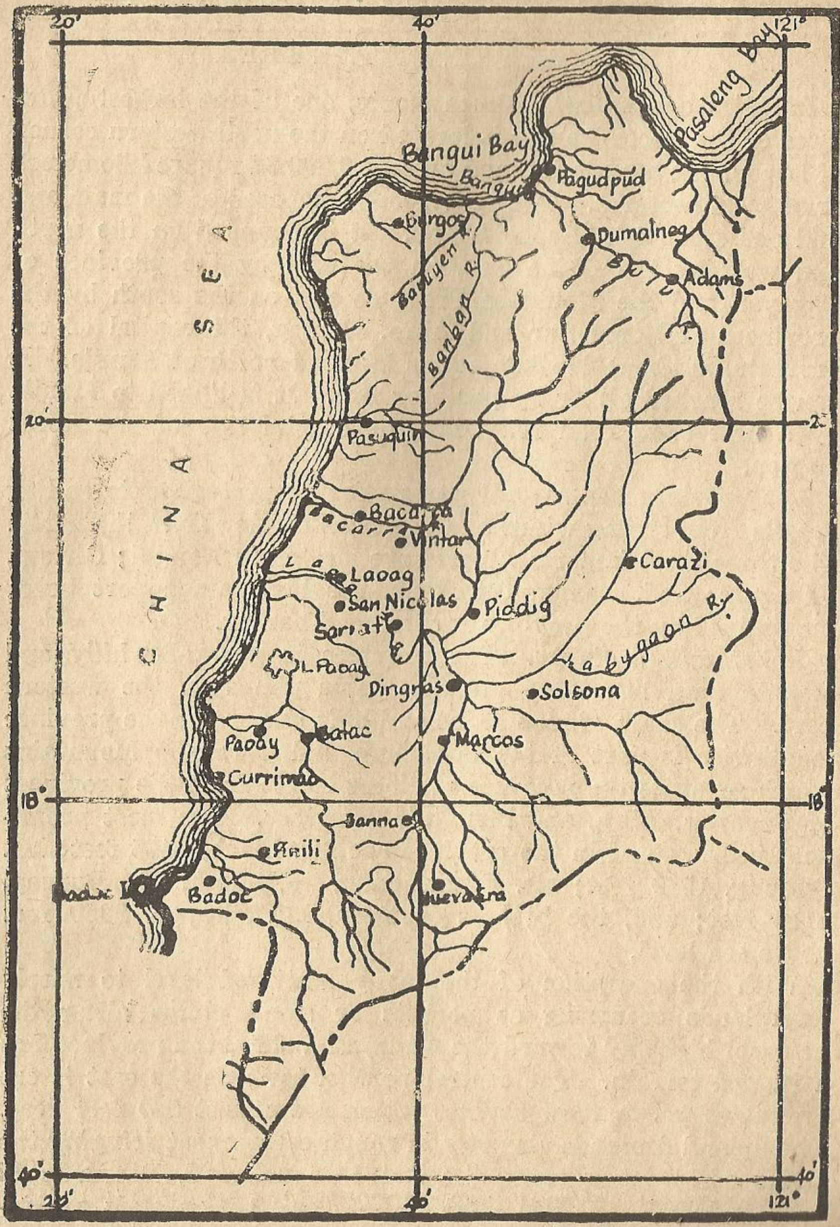

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Figure 2. Important rivers and drainage system of Ilocos Norte.

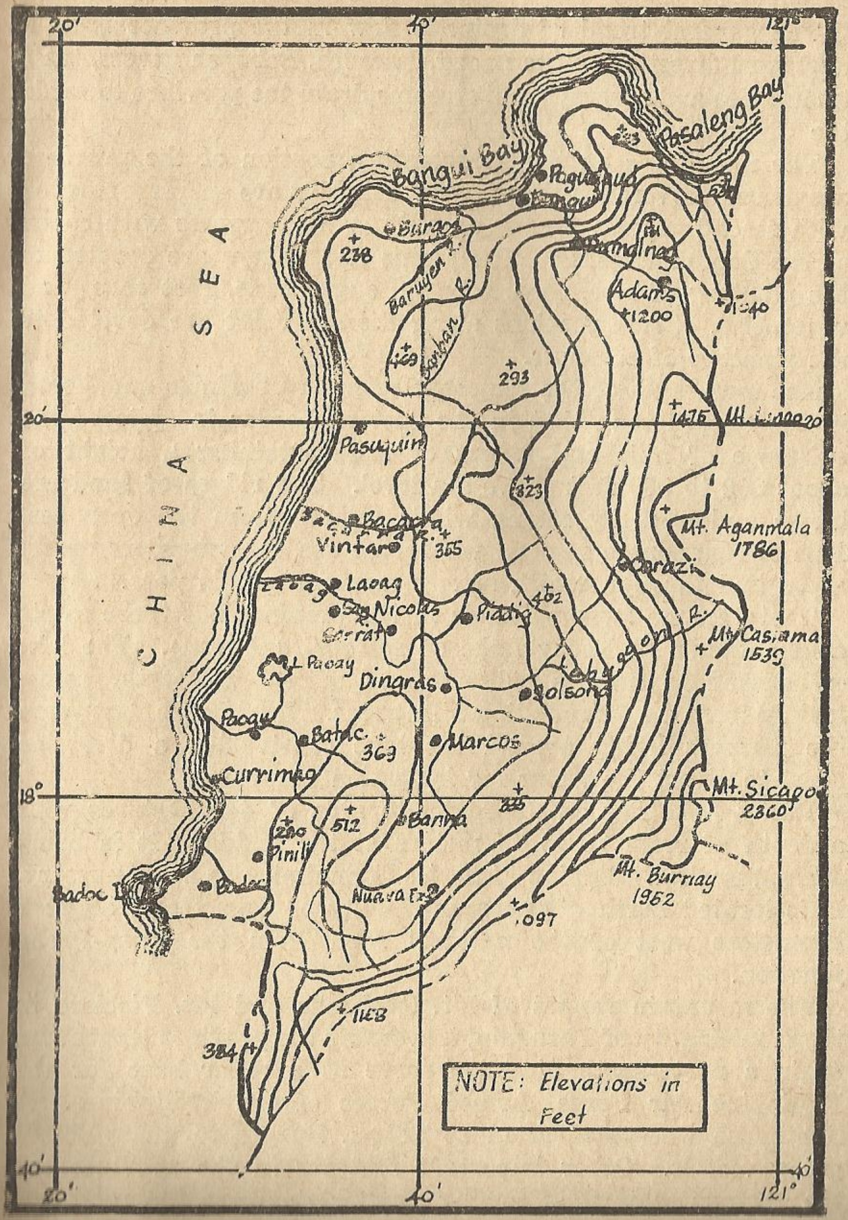

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Figure 3. Map of Ilocos Norte Province showing the general topography.

The general trend of drainage flow in the province is in a westward direction. The Laoag, Bacarra, Baruyen Rivers, their tributaries and several small streams drain the province towards the China Sea.

The mountains on the northeastern portion of the province are densely covered with forests. The hills are sparsely covered with second growth forests as well as with grasses with cogon as the dominant grass. The plains and valleys are devoted to the planting of rice, corn, tobacco, sugar cane, root crops and vegetables. Some portions along the sea coast are devoted to the planting of coconuts.

The terrain along the sea coast between Currimao and Laoag is less rugged than that in the eastern border in spite of the existence of hills and ridges of sand attaining a height of about 300 to 500 feet above sea level. The ridges of sand are blown and piled by strong winds coming from the open sea. This is common to regions where the sea coast borders desert areas and through which strong monsoon winds pass.

There are no swampy lands in the province but there exists a lake known as Paoay Lake or *Dacquel a Danum*. The lake is believed to have a subterranean outlet. Its water comes mainly from the surrounding hilly areas. During the past years the farmers living around the lake constructed a diversion canal to divert the water for irrigation purposes.

Paoay Lake has an approximate area of 440 hectares with a depth of from 10 to 15 meters at the middle. It is being utilized by the Philippine Fisheries Commission as a fish nursery. It is located north of the municipality of Paoay and about 2 kilometers west of the national road from the Baay-Paoay junction.

The mountain ranges of Mt. Quebrada and Mt. Pieolero in the municipality of Pasuquin, traversing the province lengthwise or in a north-south direction serve as a radar base for the Philippine Air Force, Armed Forces of the Philippines. A lighthouse was constructed at Bobon, Burgos to guide ocean-going vessels. Other important features in the province are the Bannua waterfalls coming from high above the road and pouring water direct to the sea and the famous Patapat Road constructed on a cliff overlooking the sea.

Along the seashore from Currimao to Paoay, Pasuquin and Burgos are found the recent coral reefs which are partly exposed during low tide. The hills along these shore lines and the rolling areas above the coastal plains are of tertiary and sediment-

ary rocks such as limestones, sandstones, conglomerates and limy shales from which the soils of the province are derived. The soils of the valleys and small pockets of plains are derived from alluvium consisting of clay, silt and sand originating from the mountain ranges and hills of the surrounding areas. These soil materials are brought down to the lowlands by water during heavy rains.

Due to the generally hilly and mountainous relief of the province drainage is good to excessive. The rivers and creeks adequately drain the soils of the province.

Water supply.—The province has inadequate water supply. The common sources of water for domestic use are native wells and some perennial streams. The dug wells are found mostly in the barrios. Water is abundant in these wells during the rainy season but the water is turbid and polluted, thus it needs a special treatment to make it potable for human consumption. During the dry season, the water table sinks considerably and some wells dry up.

Laoag, the capital of the province, has an adequate potable water supply for domestic use. This city has water resources coming from the springs of Delomut, Sumilang and Arayat. Most of the municipalities have drilled and dug wells but the water therefrom are of rather poor quality. There has been a move to improve the water facilities of the province.

Geology.—The province of Ilocos Norte has a rugged terrain and an irregular outline. The southwestern portion, which is part of the physiographic unit known as Ilocos Coast strip, consists largely of elevated coastal tract, mainly alluvium overlying older sediments with some portions of raised coral. The plain is bounded on the east by an escarpment which is partly due to a fault and partly to andesitic extrussives. The hills along the shore lines and the rolling areas above the coastal plains are of tertiary and sedimentary rocks such as limestones, sandstones, conglomerates and limy shales.

According to Smith the northern portion of the province commonly called Dungon-Dungon district is essentially one of metamorphism; namely, formation of schists, serpentinization and amphibolization. Resting above the schists is limestone of Malumbang (Pliocene) age with the Baruyen River cutting a deep canyon in this formation. The Dungon-Dungon district

Vegetation.—The vegetative cover of the province is similar to those of the other provinces in the Ilocos Region. This is perhaps attributed to the geological formation of the province being linked with the other provinces of the region. Originally, the province is widely covered with primary forest but due to shifting cultivation a large portion of this virgin forest has been reduced to secondary forest and grass.

The mountainous northern portion of the province is covered with primary forest. The primary forest consists of different species of commercial trees. Underneath the towering trees is a dense growth of vines, creepers and sapplings. The most common species of trees are:

Scientific Name	Common Name
Tarrietia sylvatica (Vidal) Merr.	Dungon
Shorea polysperma (Blanco) Merr.	Tanguile
Shorea guiso (Blanco) Blume.	Guijo
Dipterocarpus grandiflorus (Blanco)	Apitong
Anisoptera thurifera (Blanco) Blume.	Palosapis
Vitex parviflora Juss.	Molave
Pentacme contorta (Vidal) Merr. & Rolfe	White lauan
Balanocarpus cagayanensis Foxw.	Narek

The secondary or second growth forest and brushwood which cover the hills and foot-hills adjoining the primary forest consists mostly of soft-wood trees, scrub trees, shrubs and vines. In some places specially along the courses of streams there is an intergrowth of a tough spiny climbing bamboo and other vines making the forest very dense. The following are the most common trees found in the second growth forest:

Scientific Name	Common Name
Albizzia procera (Roxb.) Benth.	Akleng parang
Antidesma bunius (Linn.) Spreng.	Bignay
Antidesma ghaesembilla Gaertn.	Binayoyo
Bambosa spinosa Roxb.	Bamboo (most common species)
Gliricidia sepium (Jacq.) Steud.	Madre cacao
Schizostachyum lumampao (Blanco) Merr.	Boho
Eugenia cumini (Linn.) Druce	Duhat

The grasslands are found on rolling to hilly areas. Cogon and other drought resistant grasses are the main vegetation with sporadic growth of *duhat, binayoyo,* guava and other scrub trees. The grasslands are presently used for cattle grazing.

The crop land covers the level to nearly level and gently sloping areas. Among the most common crops planted are rice (lowland and upland), corn, tobacco (native and Virginia),

sugar cane, onion, garlic, tomato, vegetables and root crops. Bananas are planted on the sloping areas. Mongo and other leguminous crops are also planted.

There is a very small marshy area east of the road in Quiling, Batac. It is, however, so negligible that it cannot be indicated on a small scale map.

Organization and population.—The organization and growth of the province has passed through four stages, namely: Spanish period, American regime, Philippine Commonwealth, and finally, Republic of the Philippines. Before the arrival of the Spaniards there was already a region known as Ilocos which embraced the greater part of northwestern Luzon. By royal decree in 1818, the northern part was separated and created into the province of Ilocos Norte with the towns of Bangui, Nagpartian (presently Burgos), Pasuquin, Bacarra, Vintar, Sarrat, Piddig, Dingras, Laoag, San Nicolas, Batac, Paoay and Badoc. In that year the new province had a population of 135,748 people. The population has steadily increased to 251,455 in 1948 and 287,333 in 1960. The distribution of population in the province by municipality is shown in table 1.

TABLE 1.—*Distribution of population in Ilocos Norte by Municipality—Censuses of 1903 to 1960.*

Municipality	1903 March 2	1918 December 31	1939 January 1	1948 October 1	1960 February 15
Adams*	----	----	209	170	414
Bacarra	14,616	14,478	14,806	15,851	18,570
Badoc	9,240	13,147	13,231	13,573	12,210
Bangui	8,215	11,152	13,325	14,126	9,026
Banna	4,786	7,275	7,608	7,611	9,972
Batac	18,904	23,350	22,207	22,587	27,139
Burgos	1,887	2,389	2,882	3,003	3,984
Carasi *	----	----	261	231	222
Currimao	2,496	3,753	4,494	4,296	5,435
Dingras	15,641	21,388	22,434	24,481	28,308
Dumalneg *	----	----	322	454	554
Laoag	34,454	38,469	41,842	44,406	50,198
Nueva Era	----	907	2,059	1,971	2,803
Pagudpud [1]	----	----	----	----	8,702
Paoay	9,220	11,383	11,867	11,257	13,189
Pasuquin	7,040	9,192	10,065	12,407	12,262
Piddig	9,172	11,301	10,511	10,496	11,614
Pinili	4,351	5,954	7,890	8,318	10,472
San Nicolas	10,880	12,244	13,958	15,567	17,721
Sarrat	9,584	12,885	14,430	14,345	15,136
Solsona	6,864	8,176	9,032	10,423	12,043
Vintar	9,435	11,686	14,153	14,882	17,359
TOTALS	178,995	219,129	237,586	251,455	287,333

* Municipal district.

[1] Formerly part of Bangui created into Municipality by Executive Order No. 328 dated January 14, 1959 revoking Executive Order No. 240 dated February 16, 1957 abolishing the Municipality of Pagudpud, Ilocos Norte.

Spanish influx into the province began when Juan de Salcedo made his famous trip along the Ilocos Coast and during the exploration of the Laoag River in 1572. After the colonization of the province up to the establishment of a civil government in 1901 there had been several uprisings. The revolts in 1589 in Dingras and in 1660 led by Don Pedro Almazan of San Nicolas were caused by the injustices in the collection of tributes by the *encomienderos.* In 1788 another revolt took place in Laoag spurred by the general discontent of the people over the tobacco monopoly. Uprisings in the towns of Sarrat, Laoag, Batac, and Paoay led by Pedro Mateo and one known only as Ambaristo in 1807 were due to the injustices of the wine monopoly.

Like many other provinces, Ilocos Norte espoused the cause of the revolution. Gregorio Aglipay, founder of the Philippine Independent Church, was among the first to join the ranks of the revolutionists. At the height of the revolution, the revolutionary army led by Gen. Manuel Tinio occupied Ilocos Norte as well as the other provinces of the Ilocos Region in the name of the revolutionary government. Civil government was established in 1901.

To date there are twenty municipalities and three municipal districts in the province with the municipality of Marcos[1] being the latest addition.

Transportation and market facilities.—Except in the interior towns and municipal districts, transportation facilities in the province as well as to the nearby provinces and Manila are adequate. The towns needing additional buses are Nueva Era, Banna and Pinili. As of 1962[2] the province has a total of 697.594 kilometers of surfaced roads linking all the towns and some barrios, of which 299.88 kilometers were classified as first class; 216.189 kilometers, second class; and, 181.525 kilometers, third class. Of the three municipal districts only Dumalneg is accessible to motor vehicles. A logging trail constructed along the slopes of the densely forested hills and mountains links the municipal district of Adams to the national highway leading to Cagayan province. The road to Carazi has not been completed yet.

Several transportation companies operating passenger buses and freight trucks serve the province in transporting passengers as well as farm products within the province and to the nearby provinces and Manila. Among them are the Philippine Rabbit Bus Lines, Inc., Phil. United Transportation, Franco Transportation, Mendoza and Sons, Maura Transit Co., Ofelia Trans-

[1] The town was created by Republic Act No. 3753 and took effect on June 22, 1963.

[2] Data from the Office of the District Engineer, Bureau of Public Highways, Laoag, Ilocos Norte.

Scale 1:800,000

Figure 4. Map of Ilocos Norte Province showing the road system.

portation and Fariñas Transportation. The Philippine Air Lines, Inc., maintains air transportation facilities in Gabu, Laoag. Air flight services are made every day.

There is a public market in every town where most of the farm products are sold during market days. Garlic, one of the main sources of income of the farmers, finds its way to the neighboring provinces of Cagayan, Ilocos Sur, La Union, Pangasinan and the cities of Baguio, Dagupan and Manila. Virginia tobacco is sold to the FACOMAS and private dealers.

Education.—The Bureau of Public Schools and the Bureau of Private Schools operate the educational system of the province. In Laoag there are five colleges offering various courses. These are the Northern Luzon Teacher's College operated by the Bureau of Public Schools; the Northwestern Colleges, North Christian College, Saint Williams College, and Holy Ghost College which are operated by private individuals or corporations under the supervision of the Bureau of Private Schools. Public high schools as well as private high and vocational schools are found in the more progressive towns. Elementary and primary schools are found in all towns, districts and big barrios. An agricultural high school is found in Batac and in Pasuquin. As of 1962[1] there were 459 elementary schools; 9 public and 23 private high schools; 1 public and 4 private colleges. Table 2 shows the educational attainment of the population of the province as of 1960.

TABLE 2.—*Educational attainment of the population of Ilocos Norte in 1960.*

Grades completed	Total number of students	Per cent
No grade completed	116,082	40.27
Elementary 1 to 5	101,196	35.13
Elementary to high school 3	50,975	18.00
High school graduate to college graduate	19,080	6.60
TOTAL	287,333	100.00

Religion.—The church founded by the late Gregorio Aglipay in 1902 known as "Iglesia Filipina Independiente" dominates all other religious institutions in the province. Other religious denominations with relatively lesser followers are Roman Catholic, Protestant, Iglesia ni Kristo and many others. In the 1960 Census of the Philippines there were 157,972 people who believed in the faith founded by the late Gregorio Aglipay, 115,736 Roman Catholics, 7,900 Protestants, and 3,628 members of the Iglesia ni Kristo church.

[1] Data from the Office of the Division Superintendent, Bureau of Public Schools, Laoag, Ilocos Norte.

Health.—The Bureau of Health and the Bureau of Hospitals look after the welfare of the community concerning health through the puericulture centers organized in most towns. The provincial hospital located at Laoag City is fully equipped with modern hospital facilities. The Philippine National Red Cross has a branch office in Laoag and is rendering humanitarian services. There are several practicing private dentists and physicians in Laoag and in other progressive or thickly populated towns.

Lighting facilities.—Most dwellings in the towns and barrios are provided with lighting facilities. These facilities are classified according to the type of energy or fuel used for lighting purposes, namely: electricity, kerosene and oil. At present Laoag City and the towns of San Nicolas, Batac, and Paoay have electrical lighting facilities; the rest of the towns and barrios use kerosene or oil for lighting purposes.

Industries.—Majority of the people are engaged in farming. World War II has had its ill effects on the industry but due to the inherent hardworking characteristic of the people, the necessity of providing for one's existence, as well as government aid and encouragement the farming of Ilocos Norte has progressed considerably. The introduction of Virginia tobacco and cotton gave much impetus to the industry.

Due to insufficient tillable agricultural lands prevailing in the province and low crop yields, home industries were developed to supplement the farmer's income. Weaving is the principal home industry for women throughout the province. This industry was developed on a large scale in the 19th century as a result of the operations of the Real Compania de Filipinas. The textile industry incidentally encouraged the manufacture of indigo. To date, despite the establishment of modern textile industries in the suburbs of Manila, the antiquated textile weaving in the province continues to flourish.

Paoay is better known for the weaving of towels and embroidered blankets; Batac for weaving clothing materials and plain blankets; and, San Nicolas for weaving handkerchiefs.

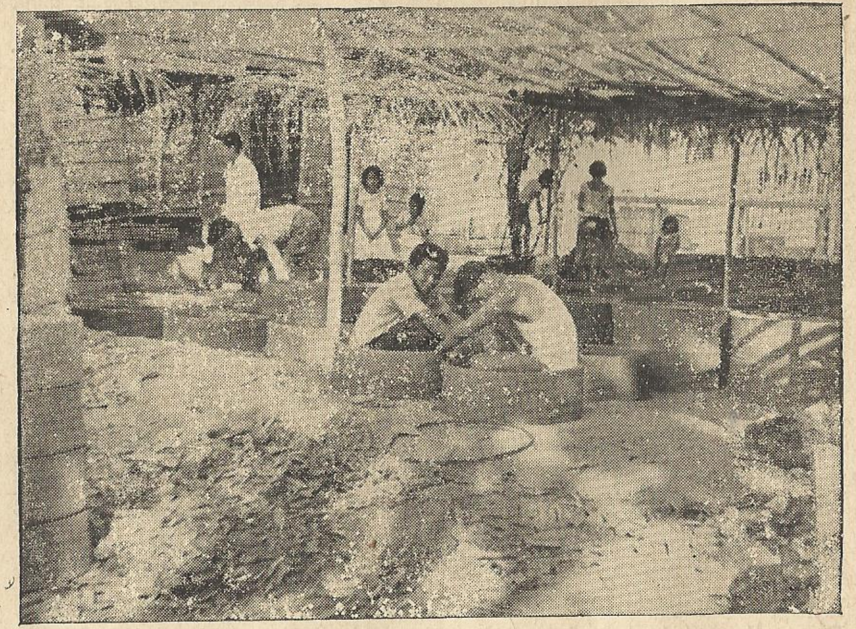


Figure 5. Pot industry in San Nicolas. Ilocos Norte. Shown are "lusob" used as walls of the wells in the province.

Figure 6. Salt making by boiling is very common in Masintoc, Paoay and in the barrios of Pasuquin along the seashore.

The seat of pottery and blacksmithing is San Nicolas while Bangui and Pagudpud are the centers of mat weaving (*pandan*) industry. Salt making is the industry of the people living in the barrios along the seashores of Paoay and Pasuquin.

Fishing is also an important industry of the province in which people who live along the shore are engaged. The China Sea is the principal fishing ground for salt-water fish and Paoay Lake and the big rivers for fresh-water fish. Fishermen use nets, hook and line, and spears for fishing. The use of dynamite in fishing has badly damaged this industry and therefore, reduced the earning capacity of the people engaged in it.

Mining of asbestos was first done in the province in 1919 from the Dungon-Dungon estate. It was, however, stopped in 1920. At present a white soil material is being mined in So. Calbaryo, Bo. Pasaleng, Pagudpud for ceramics. According to some informants an iron mine is to be opened in So. Lamen, Piddig upon completion of the road leading to the area.

CLIMATE

The province falls under the first type of climate characterized by two distinct seasons, wet and dry. The wet season usually comes in May and ends in the early part of October; the rest of the year is dry season.

The rainfall of the province has considerably decreased. The 1954 Annual Climatological Review showed that the province had an annual rainfall of 90.32 inches while the latest data obtained from the Weather Bureau Station at Gabu Airport, Laoag showed that for the last eight years (1955–1962) the average rainfall was 77.18 inches, a decrease of 13.14 inches. This decrease may be attributed to the continuous denudation of the forested hills and mountains. The heaviest rainfall occured in July 1961 and 1962 with a total precipitation of 51.45 and 49.34 inches, respectively. The incessant downpour for days brought about the swelling of the rivers and subsequent flooding of the plains of several towns. The wettest months are June, July and August while the driest months are December, January, February and March.

Temperature of the province is uniformly high. Table 3 shows that the mean monthly temperature varies from 77.2°F to 85.4°F with an annual mean temperature of 80.9°F. Gene-

045888——3

TABLE 3.—*Monthly average and annual rainfall; number of rainy days; mean, mean maximum and mean minimum temperature; relative humidity and, cloudiness in Laoag, Ilocos Norte.*

Month	Rainfall in inches [1]	Number of rainy days [1]	Temperature ° F [2]			Relative humidity %	Cloudiness [2] (0–10)
			Mean	Mean maximum	Mean minimum		
January	0.17	1	77.2	87.5	66.9	78	2
February	0.20	1	78.6	87.4	69.9	75	4
March	0.18	1	82.0	91.4	72.5	70	4
April	0.45	2	83.4	92.3	74.7	76	3
May	7.02	9	85.4	94.2	76.7	73	4
June	12.33	17	84.1	91.9	76.3	79	7
July	20.94	20	82.6	89.8	75.3	83	6
August	24.72	20	81.6	88.6	74.7	86	8
September	15.28	16	80.5	86.7	74.3	87	8
October	6.62	8	80.2	87.3	73.2	81	7
November	1.88	5	77.6	85.2	70.1	78	5
December	0.53	2	77.6	87.5	67.8	69	4
Annual	90.32	102	80.9	89.2	72.7	78	5

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

[2] Weather Bureau, *Annual Climatological Review: 1954* (Manila: Weather Bureau. 1956). p. 81.

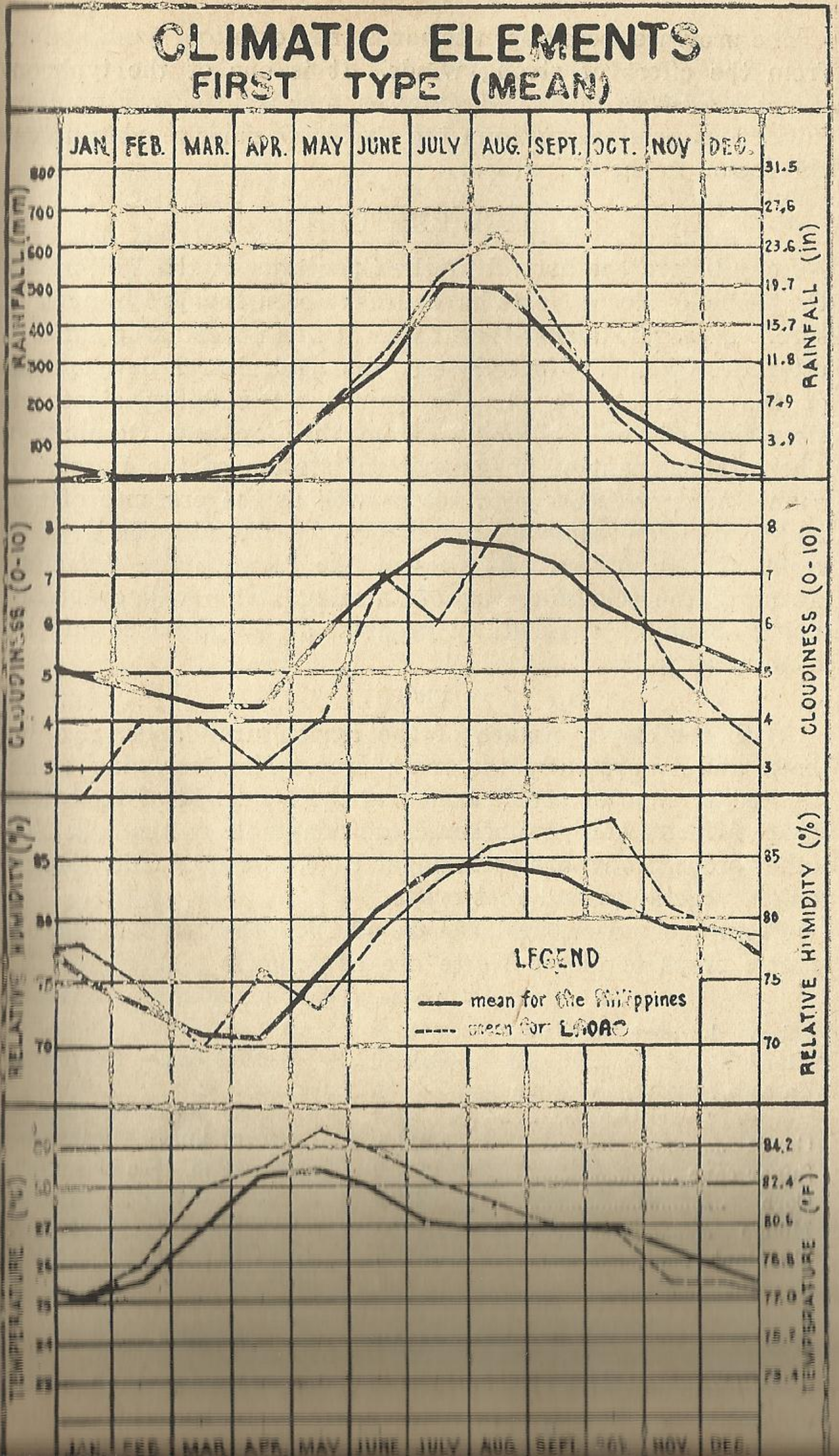
rally, the warmest months are April, May and June and the coldest months are December, January and February.

Humidity is the interaction between precipitation and temperature. It influences the growth of plants and animals. The amount of moisture that transpires from the plants and body of animals is dependent upon the relative humidity. The relative humidity of the province is rather high. The latest record at the Weather Bureau Station at Gabu Airport, Laoag based from the eight year period from 1955–1962 showed that it varies from 71.6% in April to 85.9% in August, as shown in table 4.

TABLE 4.—*Average monthly and annual temperature, rainfall, humidity and cloudiness in Ilocos Norte.*[1]

Month	Temperature °F	Rainfall in inches	Relative humidity %	Cloudiness (0–10)
January	75.6	0.21	73.9	3.5
February	76.5	0.05	72.9	2.9
March	79.6	0.10	72.8	2.6
April	82.6	0.56	71.6	2.7
May	84.1	4.21	75.4	4.8
June	82.7	14.15	82.4	7.2
July	81.5	21.01	85.2	7.8
August	81.1	23.31	85.9	8.8
September	81.1	8.78	84.0	7.2
October	81.0	3.27	78.0	5.5
November	79.5	1.44	74.8	4.9
December	77.4	0.09	73.4	3.9
Annual	80.2	77.18	77.5	5.1

[1] Data presented is the average of 8 years (1955–1962) taken directly from the Weather Bureau Station at Gabu Airport, Laoag, Ilocos Norte.



The province, being open towards the north and west, suffers from the effect of strong winds. It is one of the typhoon-swept provinces of the Philippines and is usually visited by hurricanes originating from the Pacific Ocean sweeping across the region to the China Sea.

AGRICULTURE

Long before the arrival of the Spaniards in the Philippines the people of Ilocos Norte have already been engaged in agriculture. However, during World War II this undertaking suffered utter destruction. Nevertheless, the agricultural development of the province has steadily gained its stability since the liberation of the Philippines from the Japanese Occupation. The establishment of an experiment station of the Bureau of Plant Industry in the province as well as the presence of rice and corn action teams has immensely contributed to the development of agriculture. At present the farmers are gradually adopting the scientific way of farming. This will eventually bring about the agricultural progress of the province and the country as well.

CROPS

With the clayey nature of the agricultural lands, rice has been and is presently the main crop. However, due to the limited acreage of arable land and the low yield of this staple crop, farmers cultivate other crops adaptable to the soil. The other crops grown are corn, sugar cane, mongo, garlic, tobacco, onion, vegetables and root crops.

From the agricultural census of 1960 the ten leading economic crops of Ilocos Norte are as follows:

Crop	*Area-ha.*	*Production*	*Value*
Palay, lowland & upland	30,023.3	986,063 cav.	₱9,816,137.00
Tobacco, native, Virginia & other varieties	7,110.7	4,754,839 kilos	8,865,068.00
Garlic	1,817.5	3,362,727 kilos	7,367,966.00
Sugar cane	1,098.2	61,821 m. tons	960,297.00
Corn	5,259.9	85,997 cav.	878,905.00
Mongo	1,462.1	924,883 kilos	369,137.00
Eggplant	311.6	1,420,789 kilos	250,638.00
Coconut	1,115.6	2,215,440 nuts	232,932.00
Peanuts	281.0	205,826 kilos	77,019.00
Maguey	110.1	92,665 kilos	57,990.00

Palay.—Lowland rice culture is more extensive than that of upland rice. It is grown twice a year. In the 1960 agricultural census of the Philippines, the total area devoted to this crop is 30,023.3 hectares producing 986,063 cavans of palay (44 kilos a cavan) valued at ₱9,816,137.00.

Local rice varieties such as Gallano, Burguis, Burik, and Viray which yield from 20 to 30 cavans of palay per hectare are still preferred by the farmers. However, due to their poor yield planting of certified lowland rice varieties is gaining impetus. These certified lowland rice varieties planted are Peta, BE-3, BPI-76, and Tjere Mas which yield well above the local varieties. Dry season rice culture is limited to areas where irrigation water is available.

Tobacco.—Native, Virginia, and other varieties of tobacco are grown in Ilocos Norte. According to the 1960 census the total area planted to this crop is 7,110.7 hectares with a total production of 4,754,839 kilos valued at ₱8,865,068.00.

Native varieties of tobacco have been widely grown in the province but the introduction of Virginia tobacco has decreased the area devoted to the former. Today, the municipalities of Vintar and Bacarra lead in the production of the native varieties.

The great demand for cured aromatic tobacco leaves by the cigarette manufacturers brought about the introduction of Virginia tobacco in Ilocos Norte. The government subsidy for this crop has encouraged the farmers to grow this particular crop. At present it is grown in every municipality of the province with Batac, Pinili, and Dingras leading in production. The varieties planted are Harrison Special, Golden Simox, Golden Oxford, North Carolina, and Golden Harvest producing 600 to 750 kilos of cured leaves to a hectare.

Garlic.—Garlic culture has gained importance in Ilocos Norte since the prohibition of garlic importation in the middle fifties. While no price support is given this crop some farmers preferred planting garlic than Virginia tobacco. The preference may be attributed to the exacting cultural requirements of Virginia tobacco as compared to the ease of planting garlic. Among the varieties planted are Ilocos Purple and Ilocos White which yield from 2,400 to 2,550 kilos per hectare.

According to the 1960 census of agriculture the total area planted to garlic is 1,817.5 hectares with a total production of 3,362,727 kilos valued at ₱7,367,966.00. Paoay is the leading municipality in the production of this crop.

Sugar cane.—Sugar cane is grown mostly for home consumption and for the local market. The canes are either

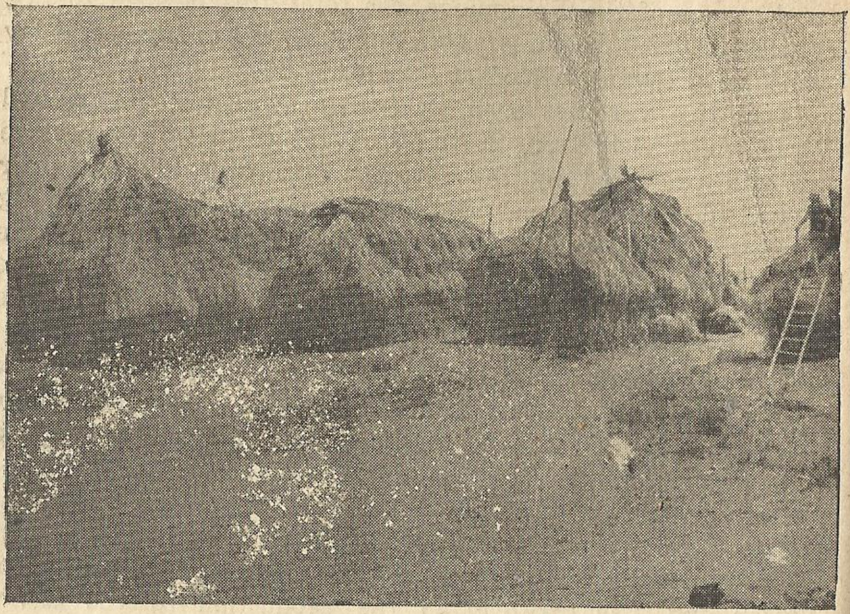


Figure 8. Stacking of rice straw is a common practice in the province. The straw is used as mulch for growing onion and garlic; after their harvest the straw is gathered and restacked for the next year.

Figure 9. Tobacco (Virginia and native) is the second most extensively cultivated crop after rice.

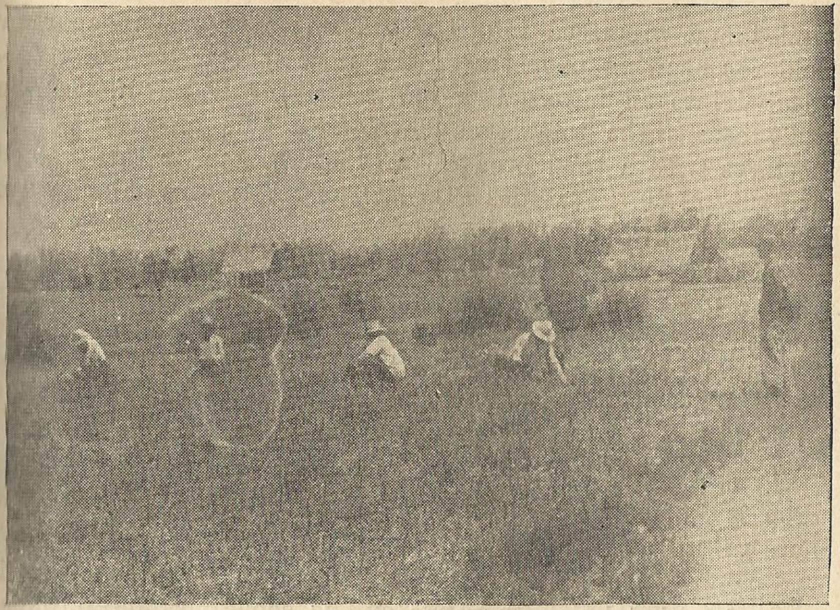


Figure 10. Garlic harvesting in Paoay, Ilocos Norte. The harvest is brought home where it is dried, cleaned, sorted and bundled for market or for storage.

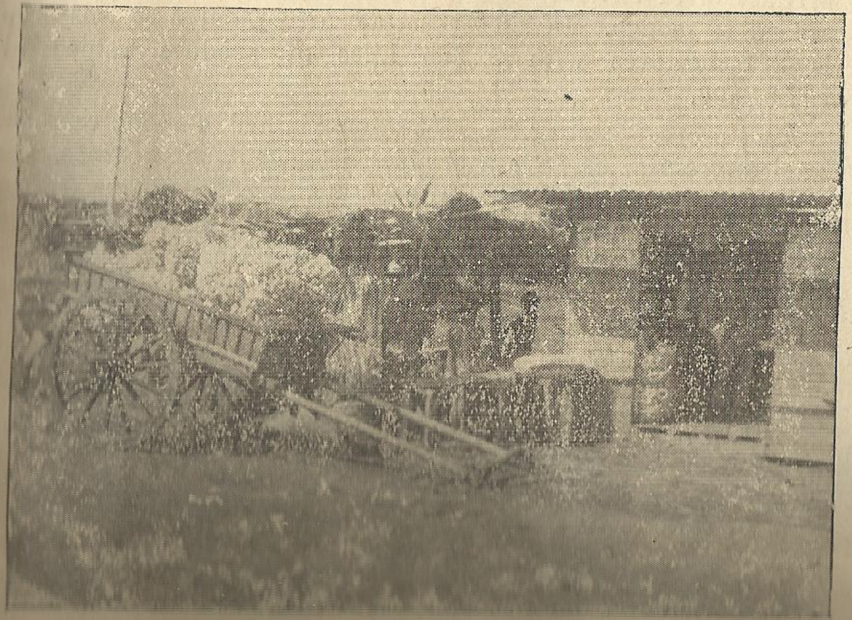


Figure 11. A cart load of garlic ready for market.

milled and processed into *panocha* and muscovado sugar or sold for chewing purposes or the juice is extracted and fermented into an intoxicating native drink called *basi.* In the 1960 census the total area devoted to this crop is 1,098.2 hectares with a total production of 61,821 metric tons valued at ₱960,297.00. Varieties POJ 2878, PSA 14, and Alunan are extensively grown.

Corn.—Corn is generally planted along borders of rice plots on the level areas and sometimes in *kaingin.* The varieties planted are Cagayan Yellow and White Flint and Glutinous White. In the 1960 census the total area devoted to this crop is 5,259.9 hectares giving a total production of 85,997 cavans of shelled corn (57 kilos a cavan) valued at ₱878,905.00.

Coconut.—In the 1960 census the total area devoted to this crop is 1,115.6 hectares with a total production of 2,215,440 nuts valued at ₱232,932.00.

Legumes.—The leading leguminous crop is mongo. It is rotated with tobacco or garlic and is sometimes intercropped with corn during the dry season. In the 1960 census the total area planted to this crop is 1,462.1 hectares with a total production of 924,883 kilos worth ₱369,137.00. Peanut ranks second to mongo. In 1960 the total area planted to this crop is 281 hectares with 92,665 kilos of produce valued at ₱77,019.00.

Root crops.—Among the root crops planted, camote, cassava, gabi ang *sincamas* gave a sizable income to the province. In 1960 the total area planted to camote was 233 hectares with a total production of 789,935 kilos worth ₱63,195.00. Cassava occupied 52.0 hectares with a total production of 425,076 kilos valued at ₱34,001.00. Gabi occupied 34.3 hectares producing 164,720 kilos valued at ₱24,708.00 and *sincamas,* 7.2 hectares with a total production of 109,398 kilos valued at ₱12,034.00.

Vegetables.—The leading vegetables planted in the province are tomato, onion, squash, patola, ampalaya, upo, cabbage, and ginger. In 1960 the area, production and value of these crops are as follows:

Crop	*Area-Ha.*	*Production (Kg.)*	*Value*
Tomato	221.9	1,114,904	₱312,173.00
Onion	154.6	491,185	250,504.00
Squash	55.0	669,545	80,345.00
Patola	36.7	254,611	85,646.00
Ampalaya	62.1	218,690	84,190.00

Figure 12. A carabao-drawn wooden sugar cane crusher at Monte, Paoay. The juice extracted is processed into *panocha* and muscovado sugar or fermented into *basi.*

Figure 13. A dry season corn crop on San Manuel silt loam.

Gourd (upo)	14.8	264,303	29,073.00
Cabbage	14.0	68,171	23,178.00
Ginger	5.7	16,716	10,716.00

Fruit trees and other cultivated fruits.—Fruit trees are mostly grown in backyards. However, banana is planted on sloping areas or at the foot of the hills.

During the 1960 census year the following fruit trees and other cultivated fruits led all others in Ilocos Norte:

Fruit trees and other cultivated fruits	*Area–ha.*	*Total No. Trees/hills*	*No.–bearing Trees/hills*	*Production Kg.*	*Value*
Mango	497.2	35,847 tr.	16,734 tr.	3,207,028	₱880,216.00
Banana	750.7	365,017 h.	—	4,741,703	531,300.00
Star apple	159.6	49,507 tr.	13,316 tr.	871,917	197,078.00
Papaya	77.5	47,194 tr.	24,388 tr.	491,622	57,960.00
Orange	21.1	9,690 tr.	4,400 tr.	133,534	38,382.00
Coffee					
Arabica	17.6	11,969 tr.	4,934 tr.	8,174)	
				)	20,147.00
Other varieties	1.9	1,599 tr.	480 tr.	1,011)	
Avocado	26.0	6,081 tr.	1,398 tr.	81,842	15,550.00
Chico	13.5	4,540 tr.	1,581 tr.	33,249	11,970.00
Sugar apple (atis)	13.9	1,713 tr.	1,252 tr.	30,477	9,143.00
Cacao	4.7	2,340 tr.	1,145 tr.	2,683	8,452.00
Jackfruit	7.1	1,441 tr.	840 tr.	51,594	8,255.00
Mandarin	1.7	1,402 tr.	361 tr.	16,642	8,155.00

Other crops.—Additional income for the province came from bamboo which yielded 2,597,793 poles worth ₱831,294.00.

AGRICULTURAL PRACTICES

Agricultural practices in Ilocos Norte do not differ much from those followed in other provinces of the country. The native wooden plow and harrow are commonly used for cultivation with the carabao as the usual source of power. The use of farm machineries is impracticable in the province inasmuch as the land holding of each farmer is limited. Clean culture, thorough land preparation, seed selection and the use of standard seed board varieties are practiced by some farmers. In the past the use of commercial fertilizers was not common, but due to the rapid decline of the farm's capacity to produce the farmers are now prompted to use either the organic and inorganic (commercial) fertilizers. Such interest in the use of fertilizer if continued by the farmers will sustain better crop production.

Shifting cultivation or *kaingin*, on the other hand, is very rampant in the interior part of the province. This system of farming accelerates soil erosion making the land unproductive in the long run. Besides, the cutting of trees and other vegetative cover may eventually change the climatic condition of the place. It is a common observation that some regions which have been enjoying a climate of no pronounced rain period and no dry season are now encountering a distinct dry season and sometimes a long drought. Flood in the lowlands oftentimes occur because nothing will hold or impede runoff. This system of cultivation must be discouraged or stopped because of its tremendous effect on the soil and crop yield. Likewise, it will destroy the lumber industry of the province.

Bench terracing is commonly employed to create rice paddies for lowland rice culture out of gently sloping areas. Usually this is accomplished by manual labor or with the aid of a work animal. The dikes are always repaired at planting time.

Crop rotation is practiced to a very limited extent. Majority of the farmers plant a sequence of crops but their soil fertility depleting characteristics are seldom taken into serious consideration.

A unique practice of the farmers in the province is the method of harvesting rice. Irrespective of the variety, bearded or non-bearded, the rice panicles are cut one by one with the use of the *rakem* and then are tied into bundles. The straw is then cut close to the ground, bundled and stacked. This straw is used as a mulch for growing onion and garlic. While in most parts of the country rice straw can be obtained free, it commands a good price, about ₱0.50 a bundle, among garlic and onion planters in the province. The straw supply may be used for two to three cropping seasons depending upon the care given to it when being stored. When the straw is no longer serviceable it is left in the field to rot or burned if the land is to be prepared at once for the following crop. Stacks of rice straw right in the field with shades to protect them from rain are a common sight in the province.

Diversified farming, inter-cropping, or catch-cropping is a common practice to increase the returns per unit area of land tilled. Diversified farming, however, is only done on elevated areas with good drainage. The most common combination of crops selected for inter-cropping are corn with peanut, corn with mongo, or corn with beans. When rain occurs before the actual start of the rainy season, the spaces between the rows of unharvested Virginia tobacco are plowed and planted to corn. This gives an additional income or food supply from the small parcel of land that each farmer cultivates aside from his regular rice crop.

The presence of the rice and corn action teams in the province is boosting the production of these staple crops. The application of commercial fertilizers is one scientific practice these teams are encouraging farmers to observe in their farms. The common fertilizers used are ammonium sulfate, 12–12–12, 12–12–10, 12–12–6, and 12–24–12 applied at the rate of from one to two bags of ammonium sulfate and/or three to five bags of any of the complete fertilizers per hectare. The high price of better quality Virginia tobacco leaves has induced the farmers to fertilize their Virginia tobacco crops, too. The most common fertilizer used is 5–10–16 applied at the rate of from three to five bags per hectare. The success of the Virginia tobacco industry of Batac enabled the Batac Producers Cooperative Marketing Association to establish a soils laboratory [1] with the aim of producing better quality flue-cured Virginia tobacco leaves.

In 1959 [2] the total irrigated area of the province was 30,010 hectares; 6,320 hectares of this total are irrigated by gravity and is maintained by the government, 5,940 hectares by community administration, 235 hectares by pumps, and 17,515 hectares by some private or communal irrigation systems.

LIVESTOCK AND POULTRY INDUSTRY

The livestock and poultry industry of the province is not well developed due to the limited area for pasture and scarcity of poultry feeds. The long dry season limits the planting of secondary crops which can be utilized for poultry and animal feeds. Cattle, carabaos and horses are the most important animals raised in the province. These are raised chiefly as work animals. Some progressive farmers have more than one of each animal and several poultry in their backyards.

[1] This soils laboratory is the first and only private soils laboratory in the Philippines. It started operation in December 1961 with the assistance of the Bureau of Soils. On September 29, 1963 the full management of the laboratory was turned over to the Bureau of Soils.

[2] DANR, *Handbook of Agriculture: 1959*, (Manila: DANR, 1959).

The number and value of livestock and poultry in the province according to the 1960 census figures are as follows:

Livestock and Poultry	*Households reporting*	*Number*	*Value*
Carabaos	33,465	61,257	₱12,493,808.00
Cattle	21,239	40,982	8,817,905.00
Hogs	45,845	82,545	4,349,840.00
Horses	2,971	5,319	875,735.00
Goats	5,086	14,531	264,411.00
Sheep	538	1,972	18,607.00
Chickens	46,396	496,632	652,339.00
Ducks	1,702	9,664	12,839.00
Turkeys	84	378	1,955.00
Geese	244	787	1,615.00
Pigeons	144	886	853.00

FARM TENURE

Farm tenure refers to the manner in which a farm is held by its operator. In farm tenure classification, the Bureau of the Census and Statistics during the 1960 census year classified farm operators into five categories; namely, (1) full owners, (2) part owners, (3) tenants, (4) farm managers, and (5) farm operators under other conditions. Tenants are further classified as (a) cash tenants, (b) fixed-amount-of-produce tenants, (c) share-of-produce tenants, (d) cash and fixed-amount-of-produce tenants, (e) cash and share-of-produce tenants, and (f) rent-free tenants.

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

Tenure of Farm Operator	*Total No. of Farms*	*Total Area of Farms-ha.*
Full owner	9,360	13,161.7
Part owner	15,132	21,107.3
Tenant:		
Cash tenant	16	16.6
Fixed-amount-of-produce tenant	338	324.8
Share-of-produce tenant	10,247	9,814.1
Cash and fixed-amount-of-produce tenant	—	—
Cash and share-of-produce tenant	53	54.0
Rent-free tenant	62	60.3
Other tenants	605	795.1
Manager	5	109.8
Other forms of tenure	—	—
	36,088	45,443.7

TYPES OF FARMS

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

The four other types of farms are: (11) hog farms with 20 or more hogs regardless of area; (12) livestock farms which satisfy any of these conditions, namely, (*a*) the area is 10 hectares or more with at least 10 heads of any specific kind of livestock and the cultivated area is less than 20 per cent of the total area of the farm, or (*b*) the area is less than 10 hectares provided there are more than 20 heads of any specific kind of livestock (except hogs) and the cultivated area of the farm is less than 20 per cent of the total area of the farm; (13) poultry farms are farms which do not qualify as crop farms and satisfy any of these conditions, namely, (*a*) there are more than 300 chickens regardless of area, (*b*) there are more than 100 laying chickens or ducks regardless of area, or (*c*) there are more than 200 other specific kinds of poultry other than chickens; and (14) other farms which are those that could not be classified under any of the aforementioned thirteen types of farms, grouped as follows: (*a*) farms planted to palay, corn, coconut, abaca, tobacco, and/or sugar cane without any of them occupying 50 per cent or more of the cultivated land, or (*b*) farms planted to other miscellaneous crops such as cotton, cacao, kapok, ramie, bamboo, etc., even if one of them occupied 50 per cent or more of the cultivated land.

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

Type of farm	Total No. of farms	Total area of farms-ha.
Palay	31,805	37,765.0
Corn	191	171.8
Sugar cane	39	28.2
Abaca	—	—
Tobacco	1,993	2,490.1
Vegetable	74	54.1
Root crop	6	1.2
Coconut	159	249.0
Fruit	133	165.9
Coffee	—	—
Hog	44	149.2
Livestock	42	1,433.4
Poultry	24	26.8
Others	1,578	2,909.0
	36,088	45,443.7

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

Size of Farm-ha.	*Total No. of Farms*	*Farms-ha. Total Area of*
Under 0.2	696	69.6
0.2 and under 0.5	5,249	1,618.5
0.5 and under 1.0	10,021	6,534.5
1.0 and under 2.0	14,125	17,399.8
2.0 and under 3.0	4,012	8,782.0
3.0 and under 4.0	1,142	3,582.7
4.0 and under 5.0	290	1,209.3
5.0 and under 10.0	400	2,503.6
10.0 and under 15.0	111	1,198.9
15.0 and under 20.0	11	184.4
20.0 and under 25.0	8	164.0
25.0 and under 50.0	10	308.8
50.0 and under 100.0	8	467.3
100.0 and under 200.0	3	390.3
200.0 and over	2	1,030.0
	36,088	45,443.7

FARM INVESTMENT

The number of selected farm equipment which corresponds to farm investment in Ilocos Norte according to the 1960 census are as follows:

Equipment	*Number*
Plows	47,847
Harrows	44,206
Tractors	35
Harvesting machines	6
Threshers	18,080
Motor vehicles	244
Sugar cane crushers	158

Stripping machines	26
Sprayers	2,653
Incubators	37

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 Tadao series was first found and classified in the vicinity of Bo. Tadao, Pasuquin.

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, Tadao sandy clay loam is a soil type within the Tadao 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 difference in relief may cause a change in the agricultural operation or change in the kind of machinery to be used. The phase of a type with a slight degree of accelerated erosion may differ in fertilizer 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 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 Faraon, Cervantes, and Bantay that are mixed together, the complex must bear the names of the dominant series, as the case may be. If there is only one dominant constituent, the complex bears the name of that series, as Bantay or Cervantes 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, telephone and telegraph lines; barrios, towns, and cities; rivers and lakes; prominent mountains, and many others.

THE SOILS OF ILOCOS NORTE

The soils of the province were classified as follows:

Soil and Miscellaneous Land Types

	Number
A. Soils of the plains and valleys:	
1. Bantog clay	228
2. Bantog clay loam	16
3. Bantog sandy loam	389
4. Bantog silt loam	390
5. Bantog silty clay	870
6. Bantog silty clay loam	391
7. Maligaya silty clay loam	383
8. San Fernando clay	68
9. San Fernando clay loam	67
10. San Fernando sandy loam	871
11. San Fernando silty clay	868
12. San Manuel clay loam	236
13. San Manuel loam	190
14. San Manuel sand	97
15. San Manuel sandy clay loam	596
16. San Manuel sandy loam	96
17. San Manuel silt loam	82
18. San Manuel silty clay	869
19. San Manuel silty clay loam	94
20. Umingan clay loam	168
21. Umingan loam	322
22. Umingan sandy loam	100
23. Umingan silty clay loam	872
B. Soils of the upland, hills and mountains:	
1. Annam clay loam	98
2. Bantay clay loam	259
3. Bantay loam	170
4. Bolinao clay	153
5. Bolinao clay loam	108
6. Bolinao loam	558
7. Cervantes clay loam	729
8. Faraon clay loam	422
9. Luisiana clay loam	140
10. Tadao sandy clay loam	867
C. Miscellaneous land types:	
1. Dune land	594
2. Mountain soils, undifferentiated	45
3. Riverwash	152
4. Rock land	599
5. Sand and coral bed	595

Table 5 shows the area and proportionate extent of each soil or miscellaneous land type in Ilocos Norte.

TABLE 5.—*Area and proportionate extent of each soil or miscellaneous land type in Ilocos Norte.*

Soil type number	Soil type or miscellaneous land type	Area [1] hectare	Per cent
228	Bantog clay	1,912.96	0.56
16	Bantog clay loam	2,284.93	0.67
389	Bantog sandy loam	106.26	0.03
390	Bantog silt loam	361.34	0.11
870	Bantog silty clay	350.71	0.10
391	Bantog silty clay loam	1,679.16	0.49
383	Maligaya silty clay loam	2,890.70	0.85
68	San Fernando clay	9,384.15	2.76
67	San Fernando clay loam	2,369.95	0.70
871	San Fernando sandy loam	403.84	0.12
868	San Fernando silty clay	701.42	0.21
236	San Manuel clay loam	1,647.27	0.48
190	San Manuel loam	9,596.70	2.82
97	San Manuel sand	170.04	0.05
596	San Manuel sandy clay loam	446.36	0.13
96	San Manuel sandy loam	4,251.03	1.25
82	San Manuel silt loam	6,217.13	1.83
869	San Manuel silty clay	1,487.86	0.44
94	San Manuel silty clay loam	913.97	0.27
168	Umingan clay loam	2,933.21	0.86
322	Umingan loam	5,090.61	1.50
100	Umingan sandy loam	223.81	0.07
872	Umingan silty clay loam	1,711.04	0.50
98	Annam clay loam	5,388.18	1.59
259	Bantay clay loam	40,469.82	11.91
170	Bantay loam	2,433.72	0.72
153	Bolinao clay	670.79	0.20
108	Bolinao clay loam	14,315.35	4.21
558	Bolinao loam	2,858.82	0.84
729	Cervantes clay loam	60,279.63	17.73
422	Faraon clay loam	5,441.32	1.60
140	Luisiana clay loam	6,270.27	1.85
867	Tadao sandy clay loam	4,729.27	1.39
594	Dune land	5,707.01	1.68
45	Mountain soils, undifferentiated	116,061.35	34.14
152	Riverwash	6,535.96	1.92
599	Rock land	7,641.23	2.25
595	Sand and coral bed	1,264.68	0.37
	Unsurveyed [2]	34.00	0.01
	Bodies of water	2,678.15	0.79
TOTAL		339,934.00	100.00

[1] Area of each soil type was determined with the use of planimeter. No deductions were made for roads.

[2] Badoc Island was not surveyed due to lack of transportation facilities.

SOILS OF THE PLAINS AND VALLEYS

The soils of the plains and valleys were formed mainly from alluvial deposits or sediments laid by water. Their colors range from very pale brown, reddish brown to black while the texture of their surface soils varies from sand to clay. External drainage is generally fair while internal drainage is poor to good. These level areas represent the most productive soils of the province. They are usually found in patches along the courses of rivers and creeks. The total area covered is estimated at 57,134.45 hectares.

BANTOG SERIES

Bantog series was first established during the reconnaissance soil survey of Bulacan province. Soils of the series were formed from water-laid sediments coming from the nearby rolling areas. The surface soil is grayish brown to dark brown sandy loam to clay. The subsoil is yellowish brown to dark brown clay loam to clay. The substratum is yellowish brown heavy clay. The relief is level. External drainage is fair while internal drainage is very poor.

Bantog clay (228).—The surface soil is grayish brown to dark brown (10YR 3/3) clay; sticky and plastic when wet. Reddish brown (5YR 5/4) streaks are present. Other profile characteristics are similar to those of Bantog silty clay loam discussed elsewhere in this report.

The soil type was found and mapped in Alabaan, Marcos, along the Dingras-Banna road; on the plain along the Batac-Badoc road; east of Batac town proper; in the Payac-Quiom-Sumader Valley, Batac; and in the vicinity of Badoc town proper. It covers a total area of about 1,912 hectares.

The principal crop grown is lowland rice. Virginia tobacco and garlic are the secondary crops grown after harvesting the regular rice crop. In Alabaan, Marcos, where there is irrigation water available throughout the year, green pepper, cabbage and onion are grown after rice. The green pepper, American variety, finds its market in Manila where it is processed into pepper sauce.

Bantog clay loam (16).—The surface soil is dark brown (10YR 3/3) clay loam; granular; slightly sticky and plastic when wet. Reddish brown (5YR 5/4) streaks are present. It is 30 centimeters thick. Other profile characteristics are similar to those of Bantog silty clay loam discussed elsewhere in this report.

The soil type was mapped southwest of Batac town proper to Bo. Mabaleng, south of the town; south of San Nicolas extending to Bo. Bingao; and west of Dingras-Banna road in Bos. Sidiran, Baldias and Ban-gay, Dingras. It covers an approximate area of 2,280 hectares.

The agricultural potentialities of the soil type are great but its extent is very limited. The principal crop is lowland rice. Virginia tobacco is planted after rice. In places where irrigation water is available, like in San Nicolas, corn, mongo and vegetables are planted. In the barrios of Camangaan, Ban-gay, Baldias, and Sidiran, Dingras, the land is tilled throughout the year. After rice, Virginia tobacco and garlic are planted which are then followed by mongo or corn.

Bantog sandy loam (389).—The surface soil is brown (10YR 4/3) sandy loam; friable; 25 centimeters thick. The subsoil is dark brown (10YR 3/3) sandy clay loam to clay loam. The texture of this layer becomes finer as its depth increases. The substratum is yellowish brown (10YR 5/6) silty clay loam.

The soil type was mapped east of Bo. Apaya, Laoag, along the Paoay-Laoag provincial road covering an area of about 106 hectares.

The main crop is upland rice. Sugar cane is planted in small scattered patches. Other crops grown after rice are sweet potato, corn, tomato, and eggplant. *Boho* grows in profusion at the foot of the hill on the eastern boundary of this soil type. Portions of the land are left uncultivated during the dry season due to lack of moisture in the soil. Soil water coming from the lower strata through capillary action is readily lost through evaporation. The texture of the surface soil partly enhances the loss of soil moisture. Green manuring and addition of organic matter to the soil will not only increase its fertility but will also improve its water retentivity.

Bantog silt loam (390).—The surface soil is pale brown (10YR 6/3) to grayish brown (10YR 5/2) silt loam; granular; friable and loose; 25 to 30 centimeters deep. Other profile characteristics of this soil type are similar to those of Bantog silty clay loam.

This soil type was found in Catuguing, San Nicolas, and immediately west of Badoc town proper bordering the dune land. It covers an approximate area of 361 hectares.

The soil type is potentially productive but the acreage is limited. The land in Catuguing, San Nicolas, is planted to upland rice during the rainy season followed by Virginia tobacco and vegetables. Sugar cane is planted in small patches for *basi* making. The land west of Badoc is devoted to lowland rice culture. Virginia tobacco, garlic and onion are grown after rice.

Bantog silty clay (870).—This soil type has similar profile characteristics to those of Bantog silty clay loam except for the color and texture of the surface soil which is grayish brown (10YR 5/2) to gray silty clay. It is sticky and plastic when wet and is about 30 centimeters thick. When puddled, as in lowland rice culture, it becomes hard and cracks upon drying forming into irregular blocks.

The soil type was mapped in Bo. Sta. Cruz, Badoc, and Capariaan, Marcos, covering as aggregate area of about 350 hectares.

The main crop is lowland rice. Although unirrigated, the farmers somehow manage to till the soil after the regular rice crop is harvested and plant it to Virginia tobacco. Due to the clayey nature of the surface soil and the lack of irrigation water, the land is limited to the cultivation of these crops. Application of agricultural lime will induce granulation and thus improve its tilth.

Bantog silty clay loam (391.)—The surfare soil is brown (10YR 5/3) to dark brown (10YR 3/3) silty clay loam; slightly friable when moist, slightly sticky and slightly plastic when wet, hard when dry; upon drying it forms into massive blocks with irregular cleavage. The boundary with the lower layer is gradual. The subsoil is dark grayish brown (10YR 5/6) silty clay loam to clay; firm when moist, sticky and plastic when wet. The boundary with the underlying layer is clear.

It was mapped as small patches of level land in-between the rolling and hilly areas along the courses of streams covering an approximate area of 1,670 hectares.

This soil type is one of the most productive soils of the province. Rice is the main crop planted. Virginia tobacco and garlic are the secondary crops commonly grown after rice.

MALIGAYA SERIES

Maligaya soils were derived from soil materials transported from the nearby rolling areas by water. These soils are characterized by a moderately developed profile and a moderately dense subsoil underlain by unconsolidated materials. Water hardly percolates through the soil. The relief is nearly level to gently

undulating. External drainage is poor to fair; internal drainage is poor. Maligaya soils are usually fine-textured making them ideal for lowland rice culture.

Maligaya silty clay loam (383).—The surface soil is pale brown (10YR 6/3) to brown (10YR 5/3) silty clay loam with red streaks; cloddy to columnar; 30 centimeters thick. The boundary with the lower layer is diffused. The subsoil is light yellowish brown (2.5YR 6/4) clay; columnar and compact. Its lower boundary is about 70 centimeters from the surface. Underneath is yellowish brown (2.5YR 6/4) gritty silty clay. Few coarse sand are present. The boundary with the upper layer is diffuse.

This soil type was found and mapped in the Banna-Nueva Era valley and in small patches of level land between rolling areas south of Banna. It covers a combined area of about 2,890 hectares.

The principal crop is rice. Virginia tobacco is planted after the rice crop. Beans, tomatoes, and vegetables are also grown in a small scale. Bamboos are found growing luxuriantly along the stream banks.

Maligaya clay loam (117).—This soil type was found within the area occupied by the silty clay loam type in Tabtabagan, Banna, but its coverage is too small to be delineated on a small scale map. The most important crops grown are rice and Virginia tobacco.

SAN FERNANDO SERIES

Soils of San Fernando series were derived from alluvial soil materials that were transported by water from the nearby uplands. They are characterized by gray to black surface soils and a dark gray to black subsoil and substratum. The relief is generally flat. External and internal drainage are both poor. These soils are deep, fine-textured and are therefore good for lowland rice culture.

San Fernando clay (68).—The surface soil is gray (10YR 5/1), dark gray (10YR 4/1) to black (10YR 2/1) massive clay; firm; sticky and plastic when wet, hard and compact when dry. The average depth is about 30 centimeters. The boundary with the lower layer is diffuse.

The subsoil is dark gray (10YR 4/1) to very dark gray (10YR 3/1) clay; firm, sticky and plastic when wet. The depth of its lower boundary ranges from 50 to 70 centimeters from the surface. Beneath this layer is dark gray (10YR 4/1) compact clay. The boundary with the upper layer is diffuse.

The soil type is the second most extensive soils of the plains covering an aggregate area of about 9,384 hectares. It occupies the plains in Paoay, Batac, Laoag, Sarrat, Piddig, and a small portion of the level area in Curarig, Bacarra.

This soil type is one of the best lowland rice fields of the province. Although the soil is difficult to plow when dry, it is nevertheless utilized for Virginia tobacco after the rice crop is harvested. Wells are dug right on the farm as means for watering the tobacco plants.

Other crops planted on a limited area are corn, garlic, and sugar cane, the latter being the source of an intoxicating native drink, called *basi*.

San Fernando clay loam (67).—San Fernando clay loam has the same profile characteristics as those of San Fernando clay. They differ in the nature of their surface soils. The former consists of gray (10YR 5/1) to very dark gray (10YR 3/1) clay loam. It is slightly sticky when wet and slightly friable when moist. It is easier to till than San Fernando clay.

It occupies the plains of Vintar; Baruyen, Bangui; Biding, Marcos; and the strip of nearly level land east of the Laoag–Paoay provincial road southwest of Paoay Lake. The soil type has an aggregate area of about 2,369 hectares.

The principal crop is rice. Virginia tobacco is planted after rice. In Vintar, where irrigation water is available, the land is cultivated throughout the year. After rice, Virginia tobacco, garlic and onion are planted. Corn and mongo follow the garlic and onion crops.

San Fernando sandy loam (871).—The surface soil is gray (7.5YR N5/) to dark gray (7.5YR N4/) sandy loam; friable; 30 centimeters deep. The boundary with the lower layer is diffuse. The subsoil is gray (10YR 5/1) sandy clay; slightly compact; slightly sticky and plastic when wet, hard when dry. The depth of its lower boundary ranges from 60 to 80 centimeters from the surface. The substratum is dark gray clay (10YR 4/1). The boundary with the upper layer is diffuse.

This soil type was mapped about a kilometer north of Pasuquin town proper.

The principal crop grown is rice after which corn, mongo and vegetables are planted. Bamboo, bancal and kamachile were observed growing luxuriantly on this soil type.

San Fernando silty clay (868).—The silty clay surface soil is sticky and plastic when wet, becomes hard when dry, especially when it is puddled for lowland rice culture.

The soil type was found in Bos. Barabar and San Antonio, San Nicolas, fringing the rolling area southwest of the San Nicolas–Dingras road and covers an area of about 701 hectares.

The soil type is utilized mostly for lowland rice culture although a very small portion is planted to sugar cane.

SAN MANUEL SERIES

San Manuel soils are the most widely distributed soils in the Philippines. They were developed from soil materials transported by water from the uplands and deposited along rivers. The profile of this series is not very well developed. The surface soil is relatively loose and very friable; easily cultivated with either native farm implements or farm machineries. The sand to sandy loam types can be plowed even after a heavy downpour. The subsoil is friable, slightly compact silt loam to fine sandy loam. The substratum is loose, usually coarser in texture than the subsoil. Drainage conditions, externally and internally, are good. These soils are ideal for crop diversification.

About 24,900 hectares are occupied by this series.

San Manuel clay loam (236).—The surface soil is grayish brown (10YR 5/2) to brown (10YR 5/3) clay loam which is slightly sticky when moist. The subsoil and substratum are similar to those of the other soil types under the series.

The soil type was mapped around the vicinity of Batac; south of Pagudpud town proper, Caunayan and in the Subec-Lusong-Burayoc area, Pagudpud. It covers an aggregate area of approximately 1,647 hectares. A small area at the Ilocos Norte-Ilocos Sur provincial boundary was also mapped under this soil type.

It is devoted to lowland rice culture during the rainy season. Other crops grown are tobacco, garlic, onion, mongo and corn. Coconut and banana are also planted in scattered patches.

San Manuel loam (190).—The surface soil is very pale brown (10YR 7/4) to pale brown (10YR 6/3) loam; loose and friable; 30 to 35 centimeters deep. Other profile characteristics of this type are similar to those of San Manuel silt loam.

This soil type was found in the plains of Badoc, Dingras, Sarrat, San Nicolas, Laoag, Paoay, Batac and Pagudpud along the courses of rivers and creeks. It is the most extensive soil of the plains, covering an aggregate area of nearly 9,597 hectares.

San Manuel loam is most ideal for farming. It is very easy to till and any crop found in the locality can be grown on it. However, lowland rice is the main crop grown. Corn, tobacco, garlic, and mongo are usually planted after rice. Preference is given to Virginia tobacco and garlic for monetary reasons. The feasibility of planting these crops, however, depends largely on the condition of the soil after rice is harvested. When the soil is too dry the land is fallowed until the rainy season sets in.

In Pagudpud, where a communal irrigation system exists, the land is planted to rice the whole year round. Irrigated areas outside Pagudpud are planted either to Virginia tobacco or garlic. In Laoag, a portion of this type is continuously cultivated to *zacate* while the other parts are devoted to truck gardening during the rainy season to supply the vegetable needs of Laoag and the neighboring towns. Corn and mongo are intercropped after tobacco and garlic are harvested.

San Manuel sand (97).—The surface soil is grayish brown (10YR 5/2) sand; loose and structureless. Other profile characteristics of this type are similiar to those of San Manuel silt loam discussed elsewhere in this report.

This soil type was found as a strip of land from Calloet, Bacarra, and Puyopuyan, Pasuquin, fringing the dune land.

Although this soil type is not suitable for rice culture rice is, nevertheless, planted as the main crop. This may be due to the fact that it is situated on a relatively low-lying area. During the rainy season the water table is very near the surface and under such a water-logged condition rice is the only crop planted. Its productivity, however, is very low. The fertility and structure of the surface soil can be improved by the addition of compost and animal dung. After rice, other crops grown are corn, sweet potato and yambean.

San Manuel sandy clay loam (596).—The surface soil is pale brown (10YR 6/3) to brown (10YR 5/3) sandy clay loam; coarse granular and friable. The other profile characteristics of this soil type are similar to those of other San Manuel soil types.

This soil type was found in the vicinity of Pasuquin town proper and Pasnga, Bacarra. It occupies an area of about 446 hectares.

Rice is the main crop. The secondary crops are corn, tobacco and vegetables. Sugar cane is also planted in small patches.

This soil type can be made more productive by following a well planned crop rotation program that will include any legume as one of the crops and by plowing under this legume the fertility of the soil is increased and its tilth is improved.

San Manuel sandy loam (96).—The surface soil is very pale brown (10YR 7/4) to brown (10YR 5/3) sandy loam; loose and very friable; 25 to 30 centimeters deep. The boundary with the lower layer is diffuse. The subsoil is pale brown (10YR 6/3) fine sandy loam; very friable; its lower boundary is about 110 centimeters from the surface. This layer is underlain by yellowish brown (10YR 5/6) sandy loam to fine sand; loose and friable. The boundary with the upper layer is diffuse.

This soil type was mapped as an irregular strip of land from Casili, Laoag, to Caruan, Pasuquin. It was also found extending from Balacad to Cavit, Laoag; in Bacsil, Paoay; and west of Paoay town proper.

The principal crop grown is rice. Other crops planted are garlic, sugar cane, sweet potato, mongo, peanut, tomato and vegetables. Mongo and other leguminous plants are planted to supplement the income of farmers from their farms. A well-planned crop rotation program to include these legumes solely as green manure is recommended to maintain the productivity of the soil as well as to increase its water retentivity.

San Manuel silt loam (82).—The surface soil is pale brown (10YR 6/3) silt loam; loose; coarse granular; friable and mellow when moist; 25 to 35 centimeters deep. The boundary with the lower layer is diffuse. The subsoil is pale brown (10YR) 6/3) silt loam to fine sandy loam with yellowish brown (10YR 5/8) streaks; slightly compact; friable; and fine granular. The lower limit of this layer is 90 to 100 centimeters from the surface. It is underlain by yellowish brown (10YR 5/6) fine sandy loam to fine sand which is slightly compact. The boundary with the lower layer is gradual.

This soil type was found in Lagsada to Nagrebcan and Paciencia, Badoc; Sumader, Batac; San Manuel, Sarrat; and in the Dingras-Solsona valley. It has an aggregate area of approximately 6,217 hectares.

The agricultural potenial of this soil is great. It is one of the most productive soils of the province. The main crop is lowland rice. Tobacco, Virginia and native varieties, and garlic are grown after harvesting the regular rice crop. Other crops grown are mongo, yambean, corn, onion and sweet potato.

San Manuel silty clay (869).—The surface soil is silty clay; slightly sticky; 30 to 35 centimeters thick. It is easily puddled and becomes hard when dry. The subsoil and substratum are more or less similar to those of other San Manuel soils.

It was found and mapped in Dingras; Laoag; Bacarra; and Sumgar, Batac. This soil type covers an aggregate area of approximately 1,487 hectares.

Lowland rice is the main crop. The secondary crops are tobacco, garlic, corn and mongo.

San Manuel silty clay loam (94).—The surface soil is light brownish gray (10YR 5/3) silty clay loam; slightly sticky when wet; friable when dry; 30 to 35 centimeters deep. The boundary with the lower layer is gradual. When the soil is puddled, as in lowland rice culture, subsequent drying causes the soil to crack into irregular blocks. The subsoil is pale brown (10YR 6/3) silt loam with yellowish brown streaks; friable; slightly compact. The lower limit of this layer is about 110 centimeters from the surface. Underneath is yellowish brown (10YR 5/6) fine sandy loam. Its boundary with the upper layer is gradual. No coarse skeleton is found in any of the horizons.

The soil type was found in the vicinities of Batac covering an area of about 913 hectares.

The land is mainly devoted to lowland rice during the rainy season. After the rice crop, either tobacco or garlic is planted followed by mongo or corn. Onion is planted in small patches. Sugar cane is also cultivated for *basi* making.

UMINGAN SERIES

Umingan series was first established during the reconnaissance soil survey of Pangasinan province. The soils of the series as found in Ilocos Norte consist of pale brown to light brownish gray to grayish brown surface soils and light yellowish brown to light olive gray subsoils. A layer of stones and gravels in the lower subsoil is the main distinguishing characteristic of the series. Like San Manuel soils, they are usually found along stream courses and on level to gently undulating areas. They are well drained, externally and internally.

Umingan clay loam (168).—The surface soil is pale brown (10YR 6/3) clay loam; granular; friable; 25 to 30 centimeters deep. When puddled, as in lowland rice culture, it becomes hard upon drying. Other profile characteristics are similar to those of Umingan loam discussed elsewhere in this report.

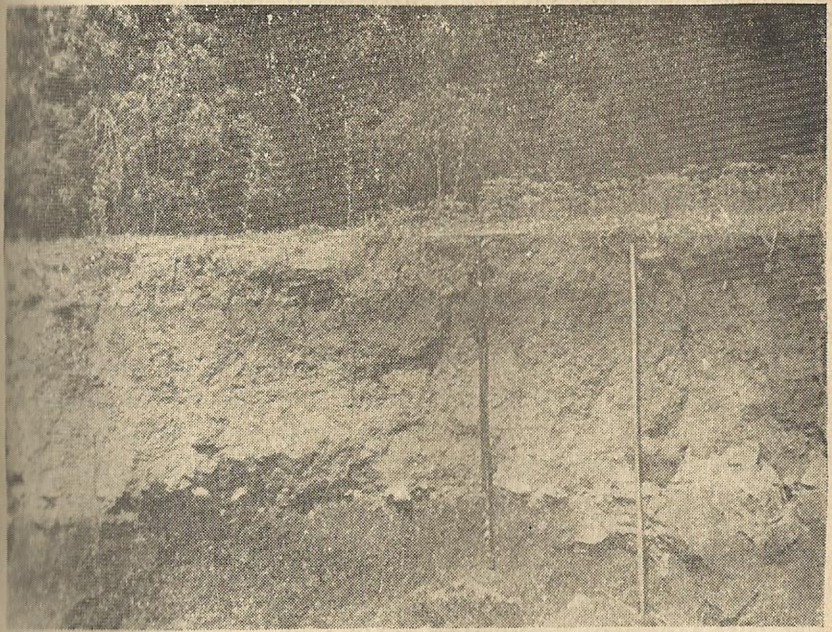


Figure 14. Profile of Umingan series. Note the layer of gravels and stones in the lower subsoil.

Figure 15. Landscape of Umingan series.

It was found and mapped in Balay-cali, Dingras, to as far as Nagpatpatan, Solsona; Abucay and Gayamat, Piddig; and, Pasaleng, Pagudpud, with an aggregate area of about 2,933 hectares.

The main crop is lowland rice. Corn, mongo and beans are planted after harvesting the regular rice crop. Whenever the soil is too dry for cultivation after the rice harvest, the land is fallowed until the rainy season comes. Sugar cane is grown in small patches for *basi* making. The land in Pasaleng is devoted to lowland rice culture only. The presence of communal irrigation system in Pasaleng enables the farmers to grow rice twice a year.

Umingan loam (322).—The surface soil is light olive gray (5Y 6/2) to pale brown (10YR 6/3) loam; loose; fine granular; very friable and mellow; 25 centimeters thick. The boundary with the lower layer is clear. The subsoil is light olive gray (5Y 6/2) to yellowish brown (10YR 5/8) fine sandy loam; loose; fine granular; and very friable. A 10–centimeter layer of stones and gravels is present in the lower subsoil. The depth of the lower limit of the subsoil varies from 90 to 100 centimeters from the surface. The substratum is light olive brown (2.5Y 5/6) sandy loam; loose and very friable. The boundary with the upper layer is abrupt.

The soil type was found in the valley between Solsona and Piddig; between Alabaan, Marcos, and Padong, Dingras; and east of Solsona town proper from Manalpac to the bases of the adjoining hills in the barrios of Cabayo, Nagsabaran, Lipay, Bago, Ditolong, municipality of Vintar. It covers an aggregate area of approximately 5,090 hectares.

The main crop is lowland rice. Corn, mongo, tomato, eggplant and beans are planted after harvesting the regular rice crop. The Lanao-Dampig plain, Bangui, classified under this type is planted to lowland rice twice a year.

This soil type is excellent for crop diversification. With enough irrigation water the land can be made productive throughout the year.

Umingan sandy loam (100).—The surface soil is pale brown (10YR 6/3) sandy loam; loose; granular; very friable; and 25 centimeters thick. Other profile characteristics of this soil type are similar to those of Umingan loam.

The soil type was found in the municipal district of Adams and in Bo. Sta. Maria, Piddig. It covers an aggregate area of some 223 hectares.

The main crop grown is rice. Other crops grown are corn, and cassava. Due to its poor water-holding capacity, this soil type is fallowed during the dry season. Addition of organic matter to the soil to increase its productivity as well as improve its water retentivity should be done.

Umingan silty clay loam (872).—Except for some differences in the surface soil, this soil type has the same profile characteristics as those of Umingan loam. It is found on nearly level areas along stream courses.

The soil type was mapped in Bo. Landing, Banna, in the south, to as far as Bo. Tabtabagan, Banna, in the north. It covers an aggregate area of about 1,711 hectares.

Lowland rice is the principal crop. Maguey, bamboo and *kakauate* are found luxuriantly growing along stream courses.

Soils of the Uplands, Hills and Mountains

Soils of the uplands, hills and mountains are derived through the weathering of various igneous rocks, shale, calcareous sandstone and coralline limestone. They are generally medium to fine textured soils (loam to clay) and exhibit a wide range of colors predominated by brown, reddish brown, red and black. Relief varies from gently sloping, rolling to hilly and mountainous.

The soil series belonging to this group are Annam, Bantay, Bolinao, Cervantes, Faraon, Luisiana and Tadao series. On account of their unfavorable relief only a limited area of these soils are cultivated to crops. They have a combined area of approximately 143,962 hectares.

ANNAM SERIES

Annam series was first established during the reconnaissance soil survey of Nueva Ecija province. It is a residual soil derived through the weathering of andesites, basalt and tuffaceous rocks. The color of the surface soil varies from grayish brown to reddish brown. The series is characterized by the presence of gravels in the subsoil. Stones, boulders and tuffaceous rocks are embedded in the substratum. The relief is rolling to hilly. External drainage is good to excessive.

Annam clay loam (98).—The surface soil is dark yellowish brown (10YR 4/4) to reddish brown (5YR 4/3) clay loam; friable; granular; and 30 centimeters deep. The boundary with the lower layer is gradual. The subsoil is dark reddish brown (5YR 4/4) clay loam; loose and friable. Stones and gravels are present. The depth of its lower boundary varies from 60 to 80 centimeters from the surface. The substratum is brown (10YR 4/3) clay loam. The boundary with the upper layer is clear. Stones, boulders and tuffaceous rocks are embedded in this layer. The relief is rolling to hilly.

The area northeast of Pagudpud, fringing the China Sea, and a small area at the road junction to Pagudpud town proper were mapped under this type. It covers an aggregate area of about 5,388 hectares. It is broken by several narrow plains.

The land is covered with non-commercial forest. It was observed during the survey that the rolling areas are being cultivated to upland rice. Bananas, pandan and betel nuts were observed growing luxuriantly. Abaca is planted in a small scale. The fibers extracted are mainly used for making ropes.

Annam loam (875).—This soil type was found within the sitio of Nagsañgo and in the barrio of Banna, Pagudpud, but its coverage is too small that it cannot be clearly indicated on the map. The natural vegetation was destroyed. Pandan and betel nuts were planted instead. The pandan leaves are used for weaving mats. A small portion of the land in Banna is devoted to upland rice while the rest is covered with brush and grass.

BANTAY SERIES

Bantay soils are primary soils developed from weathered shale. The series was first found and mapped in the vicinity of Bantay, Ilocos Sur, during the reconnaissance soil survey of that province. As mapped in Ilocos Norte, it is an extension of the same soil series in Ilocos Sur. The relief is undulating, gently rolling to rolling and hilly. External drainage is good to excessive. Internal drainage is fair. Numerous limestone precipitates are present in the lower subsoil.

The native vegetation consists primarily of grass with some scattered clusters of trees. Bamboo and *boho* are plentiful.

Bantay clay loam (259).—The surface soil is light brown (7.5YR 6/4), brown (10YR 5/3) to dark brown (10YR 3/3) clay loam; friable and granular; 15 to 20 centimeters deep. Root penetration is easy. The boundary with the lower layer is clear. The upper subsoil is dark yellowish brown (10YR 4/4) clay loam; friable; and coarse granular in structure. The lower subsoil consists of loose highly weathered shale which easily breaks into fragments under slight pressure. Lime precipitates are present. Underneath is a massive layer of highly weathered shale wherein lime precipitates are also present.

Figure 16. Profile of Bantay series. The substratum is highly weathered shale.

Figure 17. Landscape of Bantay series.

The soil type was found on gently rolling to hilly areas fringing the valleys in the southwestern part of the province with a combined area of about 40,460 hectares.

Bantay clay loam is not productive. Only a very small portion is cultivated to upland rice, corn, tobacco and vegetables. The rest is covered with grass, underbrush, and second growth forest.

Bantay loam (170).—The surface soil is brown (10YR 5/3) to dark brown (10YR 4/3) loam; friable; granular; and 15 to 20 centimeters deep. The boundary with the lower layer is gradual. The upper subsoil is yellowish brown (10YR 5/4) clay loam; friable; and coarse granular in structure. Beneath is a layer of highly weathered shale which breaks into cube-like fragments under slight pressure. Lime precipitates are present. The substratum consists of highly weathered shale.

The soil type occupies the rolling areas north of Laoag between Bos. Talatal and Ngabungab, Bacarra; east of the Bacarra-Pasuquin road fringing the coastal plain; and south of Narusodan, Badoc. It covers an approximate area of 2,433 hectares.

Like Bantay clay loam, this soil type is not agriculturally important. However, due to lack of arable land in the province the gently rolling areas are cultivated and planted to sugar cane, Virginia tobacco and upland rice. Coconuts are also planted but are limited in number. Bamboo abounds in the area. The greater portion of the soil type is covered with brush and cogon.

BOLINAO SERIES

Bolinao series are primary soils developed from coralline limestone. They are differentiated from other series of limestone origin by their dark brown to red surface soils. As mapped in Ilocos Norte, these soils occupy the nearly level to undulating, rolling and hilly areas of Burgos, Badoc and Currimao. Patches of level areas occur between hills. External drainage is good to excessive; internal drainage is poor.

Bolinao clay (153).—The surface soil is reddish brown (2.5YR 4/4) clay; granular; slightly sticky; gritty; with limestone rock outcrops. Other profile characteristics are similar to those of Bolinao clay loam discussed elsewhere in this report.

The soil type was mapped west of Badoc municipality fringing the China Sea. The relief is gently undulating. It covers an aggregate area of around 670 hectares.

A very limited area is cultivated to upland rice. Sporadic growth of maguey is found especially near the cultivated areas and along the road. The uncultivated portion is covered with second growth forest. *Kakauate* abounds in the area.

Bolinao clay loam (108).—The surface soil is reddish brown (2.5YR 4/4) to red (2.5YR 4/6) clay loam; granular; slightly sticky when wet, friable when dry; and 25 centimeters deep. The boundary with the lower layer is diffuse. The subsoil is reddish brown (2.5YR 4/4) clay loam; fine granular; compact; its lower limit is 50 to 80 centimeters from the surface. The boundary with the lower layer is diffuse. The substratum consists of a reddish brown (2.5YR 4/4) highly weathered limestone upper layer and a hard coralline limestone rock lower layer.

This soil type occupies the rolling to hilly areas in the northwestern part of the province between the towns of Burgos and Pasuquin and in the southwestern part of the municipality of Currimao. It covers a total area of about 14,315 hectares.

The principal crop is rice. Upland rice is planted on the nearly level to undulating areas. The level areas east of Currimao town proper are planted to lowland rice during the rainy season and to Virginia tobacco afterwards. Sporadic growths of maguey are also found on this soil type. *Kakauate* abounds in places formerly cultivated to crops. The rest of the area is covered with second growth forest.

Bolinao loam (558).—The surface soil is brown (10YR 5/3) to reddish brown (5YR 4/4) loam; fine granular; friable; and 30 centimeters thick. The boundary with the lower layer is gradual. The subsoil is reddish brown (3.5YR 4/4) clay loam to clay. Its boundary with the lower layer is diffuse. The upper substratum is highly weathered reddish brown limestone underlain by hard coralline limestone rock.

The soil type occupies the nearly level to undulating area east of the road between So. Diriqui, Pasuquin, and Bo. Bayog, Burgos; the nearly level area in Barat, Burgos; and the undulating to rolling area in Burgos. It covers an aggregate area of about 2,858 hectares.

Cultivated portions are planted to either rice or coconut. In Burgos where irrigation facilities exist some areas are planted to *palagad* or dry season rice. Uncultivated areas are covered with second growth forest. Sporadic growths of maguey are also found.

CERVANTES SERIES

Cervantes soils are primary soils developed through the weathering of a wide variety of igneous rocks. The series was first established in Ilocos Sur during the reconnaissance soil survey of that province. As mapped in Ilocos Norte it occupies the rolling to hilly and mountainous areas bordering the Cordillera del Norte range. A distinguishing characteristic of the series is its very friable "A" and "B" horizons and substratum. The series is similar to Alaminos and Antipolo series as to the color of their surface soils and subsoils. Beyond this, however, are differences such as in the nature of their substrata as well as in the presence or absence of concretions in their profiles. The substratum of Cervantes soils consists of loose sandy material; that of Alaminos, loose and friable clay loam; and that of Antipolo, coarse granular clay. Iron concretions are found in Alaminos and Antipolo soils while they are not present in Cervantes soils.

The external drainage is excessive; internal drainage is good.

Cervantes clay loam (729).—The surface soil is reddish brown (5YR 4/4) to red (2.5YR 4/8) clay loam; friable; slightly sticky; and 10 to 20 centimeters deep. Its boundary with the lower layer is gradual. The subsoil is yellowish red (5YR 5/8) to red (2.5YR 5/8) clay loam to clay; columnar; friable; slightly sticky. The lower limit of this layer is 120 centimeters from the surface. Stones and gravels are present. The substratum is white (2.5Y N8/) and porous sandy material which is powdery when dry. Its boundary with the upper layer is abrupt.

This soil type occupies the rolling to hilly and mountainous areas from So. Bugayan, Nueva Era, in the south, to as far as Paddaggan, Burgos, in the north and covers an approximate area of 60,279 hectares.

The soil type is not fit for clean culture crops because of its relief. The gently rolling areas may be utilized for permanent crops provided cover cropping is practiced. The grass covered areas may be used for grazing if a sound system of pasture management is followed. The greater portion of this soil type is an open cogon land with scattered growths of *binayoyo*, duhat, and shrubs.

FARAON SERIES

Faraon soils are primary soils developed through the weathering of coralline limestone. They are usually shallow. The surface soil is dark gray to black with textures ranging from

Figure 18. Profile of Cervantes clay loam.

Figure 19. Landscape of Cervantes clay loam.

clay to sandy loam. The subsoil is reddish gray to dark brownish gray clay which is coarse granular in structure. Lime gravels and cobbles are present. Underneath is massive limestone rock. The relief is rolling to hilly. Drainage is good to excessive externally and poor to fair internally.

Faraon clay loam (422).—The surface soil is dark gray (10YR 3/1) to black (10YR 2/1) clay loam; coarse granular; slightly sticky, slightly plastic when wet, friable when moist; and 20 to 35 centimeters deep. The boundary with the lower layer is clear. The subsoil is redddish gray (5YR 5/2) to dark reddish gray (5YR 4/2) clay; coarse granular; slightly sticky when wet, friable when moist. The lower boundary of this layer is about 40 centimeters from the surface. Lime gravels and cobbles are present. The upper substratum consists of highly weathered coralline limestone. Underneath is white (2.5Y N8/) massive coralline limestone rock.

The soil type was found on the rolling to hilly area which starts from the eastern part of Bo. Uguis, Nueva Era, to the eastern side of So. Tumedtedted, Batac. It covers an aggregate area of approximately 5,441 hectares.

The soil type is not fit for farming because of its unfavorable relief. The present vegetation consists of bushes, shrubs, bamboo, cogon and others.

LUISIANA SERIES

Soils of Luisiana series are derived through the weathering of various igneous rocks. They are deep and are characterized by reddish brown to red surface soils. The relief of the series is rolling to mountainous. Drainage is good to excessive externally and fair internally.

Luisiana clay loam (140).—The surface soil is reddish brown (2.5YR 5/4) to red (2.5YR 5/6) clay loam; columnar; friable; and 35 to 40 centimeters deep. The boundary with the lower layer is clear. The subsoil is light red (2.5YR 6/6) clay loam with reddish-purple streaks; slightly compact. The lower boundary of this layer is 70 to 120 centimeters from the surface. Underneath is yellowish red (5YR 5/8) clay loam with red (2.5YR 4/8) splotches; slightly sticky and plastic when wet, friable when moist. The boundary with the overlying layer is abrupt.

The rolling, hilly to mountainous area from the municipal district of Adams northwards to Bo. Pasaleng, Pagudpud, was classified under this type. It covers an area of about 6,270 hectares.

The soil type is under commercial forest, which is at present the site of logging operations. Previously cleared areas are presently covered with second growth forest and under brush. It was observed during the survey that some of the logged areas in So. Maligayligay, Adams, are being cleared by the natives for upland rice planting. This practice if continued will ultimately result in the denudation of the hills and mountains of the area.

TADAO SERIES

Tadao series is a new series established during the reconnaissance soil survey of Ilocos Norte province. It is named after Bo. Tadao, Pasuquin, where it was first identified. It is a primary soil developed through the weathering of calcareous sandstone. The relief is undulating to roughly rolling. External drainage is good to excessive while internal drainage is good.

A profile description of this series, as represented by Tadao sandy clay loam, is given below:

Depth (cm.)	CHARACTERISTICS
0—20	Surface soil, grayish brown (2.5YR 5/2) to reddish brown (5YR 5/4) sandy clay loam; loose; granular; friable when moist or dry, slightly sticky when wet. No coarse skeleton. Boundary with lower layer is gradual.
20—70	Subsoil, dark reddish brown (5YR 3/4) to red (2.5YR 4/6) sandy clay loam; columnar; friable; slightly compact. The color gradually turns yellowish red (5YR 5/6) towards the lower part of the subsoil. Boundary with lower layer is abrupt.
70—150	Substratum, very pale brown (10YR 7/4) to yellow (10YR 7/6) sandy loam to sandy clay loam; columnar; compact. Red (2.5YR 4/6) mottlings and manganese concretions are present. No coarse skeleton.

The series occupies the undulating to roughly rolling areas between Sacay, Pasuquin, and So. Alaoa-ao, Bangui, and covers an aggregate area of about 4,729 hectares.

The undesirable practice of shifting cultivation has destroyed the native vegetation. Presently this soil type is mostly under grass cover with scattered growths of *binayoyo*, duhat and guava. Cogon predominates over other grasses. Cultivated portions are either planted to rice, corn, banana or sugar cane.

Tadao sandy clay loam (867).—The profile characteristics of this soil type are given under the series.

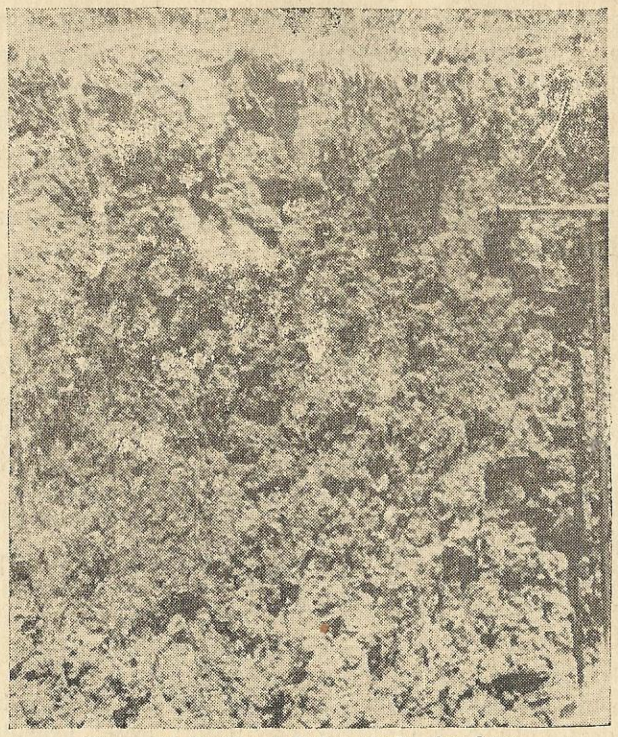


Figure 20. Profile of Tadao sandy clay loam.

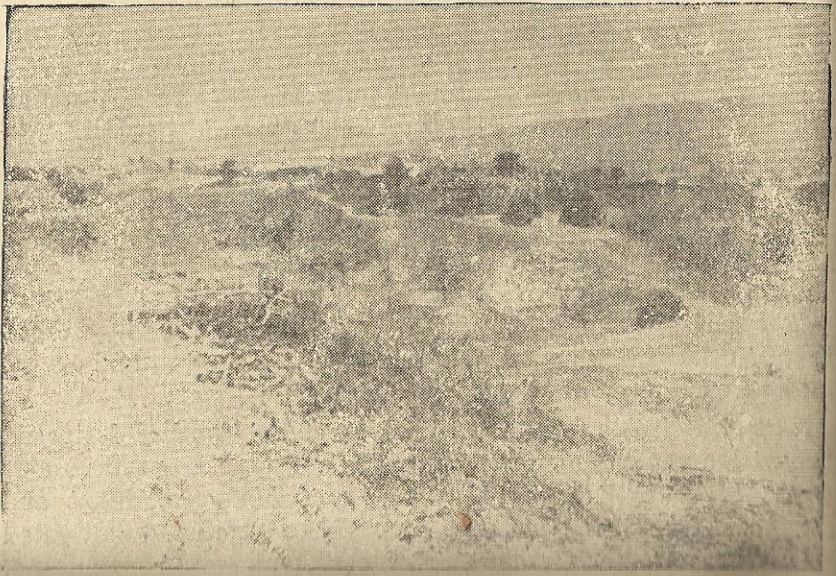


Figure 21. Landscape of Tadao sandy clay loam.

The greater portion of the land is utilized as pasture. Cultivated areas are planted to lowland or upland rice, corn, and sugar cane. The undulating portion of this soil type can be made more productive through judicious use of fertilizers and the soil can be conserved more effectively through strip cropping and by terracing. The soil is very acidic. Liming must be done to adjust the soil reaction for the requirements of most economic plants. The addition of organic matter will not only improve the fertility of the soil but also increase its water retentivity.

Miscellaneous Land Types

Areas which are without any soil cover or those covered by soil materials but exhibit no profile development are grouped under miscellaneous land types. In addition to these, where the relief, drainage, accessibility, etc., are not favorable for agriculture, such places also fall under this group. The different miscellaneous land types found in Ilocos Norte are dune land; mountain soils, undifferentiated; riverwash; rock land; and, sand and coral bed. They occupy a big portion of the province, their total area is estimated at 137,210 hectares.

Dune land (594).—This miscellaneous land type is composed of coarse to medium, light gray (10YR 7/1) to gray (10YR 6/1) sand. It occurs as strips of land along the coast of the province, the longest of which begins from Pangil, Currimao, in the south, to Estancia, Pasuquin, in the north. It covers an aggregate area of about 5,707 hectares. It is characterized by an undulating to rolling topography. The greater portion of the land is unstabilized which means that strong winds induce sand movement.

Although this land type has no agricultural value, a portion of the stabilized dune land in La Paz, Laoag, is cultivated to sugar cane, cassava and sweet potato. These cultivated crops are stunted. The native vegetation consists of vines, grass and leguminous plants. *Kakauate*, kamachile, pandan and bamboo also abound in the stabilized sand dunes or dune land.

Mountain soils, undifferentiated (45).—This land type is an extension of the same land type in the province of Abra. This hilly and mountainous land runs along the entire eastern border of the province from the south towards the China Sea in the north. It also extends eastward into the Mt. Province. The area is not very accessible. Its present forest cover should be conserved. Scattered patches of open land within

TABLE 6.—*Key to the soils and miscellaneous land types of Ilocos Norte and their respective vegetative cover.*

Soil type, miscellaneous land type number	Soil type or miscellaneous land type	Parent material or parent rock	General relief	Drainage		Present use/Vegetation
				External	Internal	
228	Bantog clay	Alluvial deposits	Level	Fair	Very poor	Lowland rice, Virginia tobacco, garlic, green pepper, cabbage, onion.
16	Bantog clay loam					Lowland rice, Virginia tobacco, corn, mongo, garlic, vegetables.
389	Bantog sandy loam					Upland rice, sugar cane, sweet potato corn, tomato, eggplant; *boho.*
390	Bantog silt loam					Upland rice, Virginia tobacco, garlic, onion, sugar cane, vegetable.
870	Bantog silty clay					Lowland rice, Virginia tobacco.
391	Bantog silty clay loam					Rice, Virginia tobacco, garlic.
68	San Fernando clay			Poor	Poor	Lowland rice, Virginia tobacco, corn, garlic, sugar cane.
67	San Fernando clay loam					Rice, Virginia tobacco, garlic, onion, corn, mongo.
871	San Fernando sandy loam					Rice, corn, mongo, vegetables; bamboo, bancal, kamachile.
868	San Fernando silty clay					Lowland rice, sugar cane.
236	San Manuel clay loam			Good	Good	Lowland rice, tobacco, garlic, onion, mongo, corn, coconut, banana.
190	San Manuel loam					Lowland rice, tobacco, garlic, corn, mongo, vegetables; grass.
97	San Manuel sand					Rice, corn, sweet potato, yambean.
596	San Manuel sandy clay loam					Rice, corn, tobacco, vegetables, sugar cane.
96	San Manuel sandy loam					Rice, garlic, sugar cane, sweet potato, mongo, peanut, tomato, vegetable.
82	San Manuel silt loam					Lowland rice, tobacco, garlic, mongo, yambean, corn, onion, sweet potato.
869	San Manuel silty clay					Lowland rice, tobacco, garlic, corn, mongo.
94	San Manuel silty clay loam					Lowland rice, tobacco, garlic, mongo, corn, onion, sugar cane.
168	Umingan clay loam		Level to gently undulating			Lowland rice, corn, mongo, sugar cane, beans.
322	Umingan loam					Lowland rice, corn, mongo, tomato, bean eggplant.
100	Umingan sandy loam					Rice, corn, cassava.
872	Umingan silty clay loam					Lowland rice; maguey, bamboo, *kakauate.*
383	Maligaya silty clay loam		Nearly level to gently undulating	Poor to fair	Poor	Rice, tobacco, beans, tomato, vegetables; bamboo.

TABLE 6.—*Key to the soils and miscellaneous land types of Ilocos Norte and their respective vegetative cover*—continued

Soil type, miscellaneous land type number	Soil type or miscellaneous land type	Parent material or parent rock	General relief	Drainage		Present use/Vegetation
				External	Internal	
158	Bolinao clay	Coralline limestone	Nearly level to gently undulating, rolling and hilly	Free to excessive	Poor	Upland rice; maguey, *kakauate;* second growth forest.
108	Bolinao clay loam					Rice, tobacco; maguey, *kakauate;* second growth forest.
558	Bolinao loam					Rice, coconut, maguey; second growth forest.
867	Tadao sandy clay loam	Calcareous sandstone	Undulating to roughly rolling	Good to excessive	Good	Rice, corn, sugar cane, banana; *binayoyo* duhat, guava; grass.
259	Bantay clay loam	Shale	Undulating to gently rolling, rolling and hilly		Fair	Upland rice, corn, tobacco, vegetables; grass; second growth forest, underbrush.
170	Bantay loam					Upland rice, tobacco, sugar cane, coconuts; bamboo; cogon; brush.
98	Annam clay loam	Andesite, basalt and tuffaceous rock	Rolling to hilly			Upland rice, banana; abaca; pandan, betel palm; non-commercial forest.
422	Faraon clay loam	Coralline limestone				Bamboo, bushes, shrubs; grass.
729	Cervantes clay loam	Igneous rocks	Rolling to hilly and mountainous	Excessive	Good	*Binayoyo,* duhat, shrubs; grass.
140	Luisiana clay loam			Good to excessive	Fair	Commercial forest, second growth forest, underbrush.
594	Dune land		Undulating to rolling	Excellent	Excellent	Sugar cane, cassava, sweet potato; *kakauate,* kamachile, pandan, bamboo, vines; grass.
45	Mountain soils, undifferentiated		Mountainous			Forest.
152	Riverwash					Agoho, kamachile, *dumanay* (shrub).
599	Rock land					Wildlife.
595	Sand and coral bed					Shrubs; maguey; salt bed.

the area should be reforested immediately. About 116,061 hectares were classified under this miscellaneous land type.

Riverwash (152).—This land type is brought about when a stream or river changes its course or when it runs dry. The resultant barren strip, which is usually covered with sand, gravels and stones, is classified as riverwash. Banks of live streams or rivers which are covered with gravels, stones and boulders are also considered riverwash.

The most extensive riverwash areas of the province are found in the municipalities of Dingras, Banna, Solsona and Vintar. Native vegetation consists of agoho, kamachile, and *dumanay*. This land type covers an aggregate area of about 6,535 hectares.

Rock land (599).—This land type as found in the province is composed of rocks, most of which are coralline limestones. In some places there are very thin layers of soil materials on top of the rock unto which some plants have taken a foothold. Rock land was mapped from Bo. Similla, Pasuquin, to Blanca Point, Bangui. A small area is found in La Paz, Laoag. It covers an aggregate area of about 7,641 hectares.

The rocks when quarried serve as good surfacing material for roads.

Sand and coral bed (595).—This land type is composed of a layer of white (10YR 8/1) to light gray (10YR 7/1) sand and pulverized corals and shells about 50 centimeters deep and underlain by corals. It was found between the national road and the coast from Caruan, Pasuquin, to Cabarabaan, Burgos. It covers an approximate area of 1,264 hectares.

The native vegetation consists mostly of shrubs. Maguey is the only economic crop found growing on this land type. In Diriqui, Pasuquin, a section of this miscellaneous land type is used for salt making.

LAND-USE AND SOIL MANAGEMENT

The term "land-use" refers to the general use of the land such as for (1) farm crops, (2) permanent pasture, and (3) forest. Soil management refers to the operations done on the farm such as (1) method of tillage, (2) choice and rotation of crops, (3) application of fertilizers and soil amendments, and (4) control of run-off.

The soils of the plains and valleys are suited for intensive cultivation with easily applied conservation practices. These soils belong to the Bantog, Maligaya, San Fernando, San Manuel and Umingan series. Although these soils may be fertile they could become submarginal in the coming years if they are continuously cropped without instituting proper soil management practices. During the survey it was observed that most of the arable lands are under continuous cultivation, but fertilization is rather haphazard. Replacement of plant nutrients depleted through continuous cropping is neglected or is given very little consideration. The leguminous crops planted add very little nitrogen to the soil because legumes are grown not as green manure crops but are raised to supplement the income from the farm. Crop rotation and green manuring, cheap means of maintaining soil fertility, are known by only a very few farmers.

The area of arable land is so limited that some farmers resort to the cultivation of hillsides. Slopes are plowed up and down thereby enhancing soil erosion. Likewise, shifting cultivation is rampant in forested areas. Upland soils like Bantay clay loam, Bolinao clay loam, Annam clay loam and Tadao sandy clay loam, which are only suited to permanent crops or forest on account of their rolling topography, are planted to clean culture crops such as rice, corn, tobacco and vegetables. Contour tillage, terracing and/or strip cropping are not practiced thus these soils are now slightly to moderately eroded.

The need to change from the old system of farming to the scientific way by farmers of the province should be given serious thought and the proper encouragement to implement it should not be overlooked. The farmers should be made to understand that plowing up and down slopes and *kaingin* farming are wasteful and detrimental to the nation's economy. They should be made to know that continuous cultivation of the land calls for soil conservation measures such as green manuring, cover cropping and the application of organic and commercial fertilizers. Above all, farmers should be taught to utilize the land according to its capabilities.

WATER CONTROL ON THE LAND

Water control in the province of Ilocos Norte covers the use of water for irrigation purposes, the protection of the land from floods and the control of runoff and soil erosion.

During the rainy season, which is from May to October, there is enough rainfall for crop needs. However, during the dry season, which is from November to April, water is not available. The construction of irrigation systems is, therefore, of primary importance.

The occurrence of dry periods during the flowering and milking stages of rice has caused so many crop failures. With irrigation systems to supply water when needed these crop failures will not only be avoided but crop yields per unit area could be substantially increased. Early maturing varieties could be supplanted by late maturing varieties, which are relatively high yielders. Moreover, the areas which remain idle after harvesting the regular rice crop can again be utilized for planting *palagad* rice or secondary crops such as tobacco, corn, garlic, mongo, etc. It is worthwhile to mention that due to the resourcefulness and industry of the farmers in the province unirrigated lands instead of being left idle during the dry season are made productive. Farmers have dug deep wells (*bito*) right on their farms from which water is drawn for their cash crops such as Virginia tobacco and garlic.

Communal irrigation systems are found in every municipality of the province and these systems cover an aggregate area of 32,924.31 hectares.[1] However, most of the facilities are of the makeshift type and during floods most of the structures are often damaged. Furthermore, only a very few of these irrigation systems actually function during the dry season when they are needed most, because most streams and rivers run dry or their water level become so low.

There are three government-owned irrigation systems in the province; namely, Bonga No. 2, which is a water pumping station operating in San Nicolas; Dingras Irrigation System in Dingras; and, Laoag-Vintar Irrigation System in Vintar. The three systems have a combined coverage of 5,390.72 hectares and serve the municipalities of Pasuquin, Bacarra, Sarrat, Vintar, Dingras and San Nicolas, and Laoag City.

The denudation of the rolling and hilly areas of the province has consequently brought about the problem of flood and soil

[1] The figure was obtained from the Irrigation Division, Bureau of Public Works, Laoag, Ilocos Norte. It represents the irrigable area as of December, 1962.

erosion. During the rainy season excessive runoff washes away precious top soil, swells creeks and rivers, and in some places the on-rushing water destroys crops and deposits sand, gravels and stones on some low-lying fields. Runoff also strengthens current flow and in the process stream banks are washed away.

The problem of flood and erosion control in the province can be minimized by implementing the following:

1. Immediate reforestation of the denuded areas. Further destruction of the native vegetation of the hills and mountains must be stopped.

2. The land should be used according to its capabilities. Level lands are good for extensive farming but rolling lands are only good for occasional cultivation and are best suited for permanent crops.

3. River or stream banks must be protected. Seeding the river or stream banks with fast growing trees will protect them from further erosion. The present vegetation along the river banks must be left intact.

PRODUCTIVITY RATINGS OF THE SOILS OF ILOCOS 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 7 indicates the productivity ratings of the soils of Ilocos 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 for a

TABLE 7.—*Productivity ratings of the soils of Ilocos Norte.*

Soil type number	Soil type	Crop productivity index for[1]: Lowland rice 100=60 cavans	Upland rice 100=20 cavans	Corn 100=17 cavans	Native tobacco 100=1,475 kilograms	Virginia tobacco 100=710 kilograms	Garlic 100=2,475 kilograms	Onion 100=4,915 kilograms	Mongo 100=7 cavans	Sweet potato 100=8 tons
98	Annam clay loam	x	x	x	x	x	x	x	x	x
259	Bantay clay loam	x	x	x	x	x	x	x	x	x
170	Bantay loam	x	x	x	x	x	x	x	x	x
228	Bantog clay	48	101	68	x	100	102	98	x	x
16	Bantog clay loam	49	100	67	69	107	x	97	x	x
389	Bantog sandy loam	x	98	76	x	x	x	x	x	56
390	Bantog silt loam	47	98	62	67	97	100	96	96	56
870	Bantog silty clay	48	107	x	x	97	x	x	x	x
391	Bantog silty clay loam	49	100	68	68	101	x	x	x	x
153	Bolinao	x	55	xx	x	x	x	x	x	x
108	Bolinao clay loam	46	55	x	x	x	x	x	x	x
558	Bolinao loam	46	62	60	x	x	x	x	x	x
729	Cervantes clay loam	x	x	x	x	x	x	x	x	x
422	Faraon clay loam	x	x	x	x	x	x	x	x	x
140	Luisiana clay loam	x	x	x	x	x	x	x	x	x
383	Maligaya silty clay loam	47	109	64	64	90	94	x	90	x
68	San Fernando clay	48	103	68	70	101	98	98	x	x
67	San Fernando clay loam	41	102	65	69	95	97	101	106	49
871	San Fernando sandy loam	46	98	65	x	x	94	x	98	56
868	San Fernando silty clay	46	x	65	x	x	x	x	x	x
236	San Manuel clay loam	47	101	74	71	103	97	94	x	x
190	San Manuel loam	48	104	73	67	103	98	98	106	51
97	San Manuel sand	30	x	58	x	x	x	x	x	56
596	San Manuel sandy clay loam	47	97	74	75	97	94	97	95	52
96	San Manuel sandy loam	48	102	70	64	100	97	99	99	50
82	San Manuel silt loam	49	104	70	70	97	99	98	100	52
869	San Manuel silty clay	50	107	74	74	109	98	101	100	x
94	San Manuel silty clay loam	50	103	71	x	104	95	97	98	56
867	Tadao sandy clay loam	x	58	x	x	x	x	x	x	x
168	Umingan clay loam	48	105	71	x	95	x	x	95	50
322	Umingan loam	48	106	71	68	95	99	98	x	52
100	Umingan sandy loam	46	100	71	x	x	x	x	x	45
872	Umingan silty clay loam	47	105	70	67	98	95	x	x	84

[1] Soils are given indexes that give the approximate average production of each crop in per cent of the standard of reference. The standard represents the approximate average yield obtained without the use of fertilizer or soil amendments on the more extensive and better soil types of the Philippines on which the crop is most widely grown.

[x] This symbol means that the crop is not grown on the soil type, or the crop is grown on a small scale.

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 wherein the national standard is 60 cavans of palay.

TEXTURAL CLASSES OF THE SOILS OF ILOCOS 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 millimeters 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, so that all soils containing 40 per cent or more of clay are classified as clay soils.

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

TABLE 8.—*Average mechanical analyses of the surface soils of the different soil types of Ilocos Norte by the Bouyoucos method.*

Soil type Number	Soil type	Sand (2.00–0.05 mm.)	Silt (0.05–0.002 mm.)	Clay (0.002 mm)
		Per cent	Per cent	Per cent
98	Annam clay loam	31.2	40.0	28.8
259	Bantay clay loam	29.8	34.0	36.2
170	Bantay loam	49.4	28.0	22.6
228	Bantog clay	13.8	35.4	50.8
16	Bantog clay loam	25.2	38.0	36.8
389	Bantog sandy loam	78.4	10.4	11.2
390	Bantog silt loam	17.4	59.8	22.8
870	Bantog silty clay	12.2	42.0	45.6
391	Bantog silty clay loam	19.4	43.8	36.8
153	Bolinao clay	29.4	26.0	44.6
108	Bolinao clay loam	30.4	40.4	29.2
558	Bolinao loam	42.2	35.6	22.2
729	Cervantes clay loam	21.2	42.0	36.8
422	Faraon clay loam	37.4	36.0	31.6
140	Luisiana clay loam	37.2	35.2	27.6
383	Maligaya silty clay loam	19.8	51.4	28.8
68	San Fernando clay	13.4	35.8	50.8
67	San Fernando clay loam	28.2	35.6	36.2
871	San Fernando sandy loam	55.2	27.6	17.2
868	San Fernando silty clay	9.2	44.0	46.8
236	San Manuel clay loam	22.8	43.6	33.6
190	San Manuel loam	43.2	31.6	25.2
97	San Manuel sand	89.8	3.6	6.6
596	San Manuel sandy clay loam	52.4	26.0	21.6
96	San Manuel sandy loam	52.8	27.6	19.6
82	San Manuel silt loam	20.4	58.0	21.6
869	San Manuel silty clay	9.8	47.4	42.8
94	San Manuel silty clay loam	17.4	54.0	28.6
867	Tadao sandy clay loam	65.4	13.8	20.8
168	Umingan clay loam	42.8	23.6	33.6
322	Umingan loam	44.8	39.6	15.6
100	Umingan sandy loam	53.8	29.0	17.2
872	Umingan silty clay loam	16.8	45.6	37.6

[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 ILOCOS NORTE

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

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

The different land capability classes are as follows:

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

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

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

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

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

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

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

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

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

LAND CAPABILITY CLASS A

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

San Manuel clay loam
San Manuel loam
San Manuel sandy clay loam
San Manuel sandy loam
San Manuel silt loam
San Manuel silty clay
San Manuel silty clay loam

TABLE 9.—*Land capability classification of the different soil and miscellaneous land types of Ilocos Norte.*

Soil type number	Soil/miscellaneous land type	Possible soil unit[1] (Slope-erosion class)	Land capability class
236	San Manuel clay loam		
190	San Manuel loam		
596	San Manuel sandy clay loam		
96	San Manuel sandy loam	a-O	A
82	San Manuel silty loam		
869	San Manuel silty clay		
94	San Manuel silty clay loam		
97	San Manuel sand		
168	Umingan clay loam		
322	Umingan loam	a-O	Bs
100	Umingan sandy loam		
872	Umingan silty clay loam		
228	Bantog clay		
16	Bantog clay loam		
389	Bantog sandy loam		
870	Bantog silty clay		
391	Bantog silty clay loam		
390	Bantog silt loam	a-O	Bw
383	Maligaya silty clay loam		
68	San Fernando clay		
67	San Fernando clay loam		
871	San Fernando sandy loam		
868	San Fernando silty clay		
98	Annam clay loam		
259	Bantay clay loam		
170	Bantay loam	b-1	Be
153	Bolinao clay	c-1	Ce
108	Bolinao clay loam	d-1	De
558	Bolinao loam		
867	Tadao sandy clay loam		
		b-1	Be
729	Cervantes clay loam	c-1	Ce
140	Luisiana clay loam	d-1	De
		e-1	M
422	Faraon clay loam	c-2	M
		d-2	N
45	Mountain soils, undifferentiated		N
594	Dune land		
152	Riverwash		X
599	Rock land		
595	Sand and coral bed		

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

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

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

This class is suited for intensive cultivation and all crops common in tne area can be grown. Since soils under this class have good permeability, if lowland rice is to be grown, puddling the soil is usually necessary to minimize seepage.

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

Land Capability Class B, Subclass Be

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

Annam clay loam
Bantay clay loam
Bantay loam
Bolinao clay
Bolinao clay loam
Bolinao loam
Tadao sandy clay loam
Cervantes clay loam
Luisiana clay loam

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

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

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

In addition to erosion control measures the proper kind and quantity of fertilizer and lime should be applied. Crop rotation should be observed wherein a legume is included in the sequence at least once in every three or four years for soil

building purposes. For all legumes, the soil should be well supplied with lime and a phosphate-carrying fertilizer; if the soil does not contain the right kind of bacteria it should be inoculated accordingly. The use of farm manure or compost is recommended.

Land Capability Class B, Subclass Bs

Nearly level. Low fertility, shallowness, droughtiness, slight alkalinity or salinity is/are the problems. Adopt special soil management practices and observe easily applied conservation practices.

San Manuel sand
Umingan clay loam
Umingan loam
Umingan sandy loam
Umingan silty clay loam

Subclass Bs is nearly level land with sandy loam or light textured subsoils.

This subclass is potentially good land but the soil is inherently low in fertility and its porous subsoil allows water to percolate rapidly thus making it somewhat droughty. Moreover, fertility loss through leaching is relatively high.

Fruit trees, vegetables, and other truck and special crops are best adapted to this land.

Special soil management practices and the observance of easily applied conservation practices are necessary. To enhance and maintain productivity the plant nutrient and organic matter contents of the soil should be always at their highest possible level. This means using a system of crop rotation which must include a legume at least once in every three or four years, the addition of farm manure or compost, and the application of mineral fertilizers. Increasing the organic matter content of the soil increases its water-holding capacity and also improves its tilth and fertility. Supplemental irrigation may be needed during the dry season for best growth of all crops.

Land Capability Class B, Subclass Bw

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

Bantog clay
Bantog clay loam
Bantog silty clay
Bantog silty clay
Bantog silty clay loam
Bantog silt loam
Maligaya silty clay loam
San Fernando clay
San Fernando clay loam
San Fernando sandy loam
San Fernando silty clay

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

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

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

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

LAND CAPABILITY CLASS C, SUBCLASS Ce

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

Annam clay loam	Bolinao loam
Bantay clay loam	Tadao sandy clay loam
Bantay loam	Cervantes clay loam
Bolinao clay	Luisiana clay loam
Bolinao clay loam	

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

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

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

mize erosion the most important of which are contour tillage, strip cropping, cover cropping, grassed waterways, and terracing. In addition lime and fertilizer according to needs, should be applied; compost and farm manure should be incorporated into the soil; and green manuring must be observed regularly.

LAND CAPABILITY CLASS D, SUBCLASS De

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

Annam clay loam	Bolinao loam
Bantay clay loam	Tadao sandy clay loam
Bantay loam	Cervantes clay loam
Bolinao clay	Luisiana clay loam
Bolinao clay loam	

Subclass De is strongly sloping and is severely to very severely eroded land. The topsoil is generally thin; the subsoil is usually heavy and slowly permeable.

The slope, which ranges from 15 to 25 per cent, and the heavy and slowly permeable subsoil induce moderate to excessive runoff. Consequently the danger of soil erosion is increased. The topsoil being thin, accelerated erosion on this land will be very critical both on the standpoint of effective soil depth and fertility. The lack of soil depth for good root penetration and water intake and storage are added problems to cope with.

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

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

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

It is best suited to pasture or forest.

Land Capability Class M

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

Cervantes clay loam
Faraon clay loam
Luisiana clay loam

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

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

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

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

Land Capability Class N

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

Faraon clay loam
Mountain soils, undifferentiated

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

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

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

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

Land Capability Class Y

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

Dune land
Riverwash
Rock land
Sand and coral bed

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

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

II. SOIL EROSION SURVEY

SOIL EROSION DEFINED

Soil erosion is defined as the process of soil detachment and transportation by either wind or water. There are two kinds of erosion; namely, normal or geologic and accelerated erosion.

Normal or geologic erosion.—Normal or geologic erosion takes place in a natural or undisturbed condition under the canopy of forest, grass, ground litter, and in underground network of binding roots. Geologic erosion is a slow process; the removal of the soil by either water or wind is balanced by the formation of soil from the parent material underneath. This kind of erosion is beneficial in the sense that there is a constant renewal of the fertility of the soil.

Accelerated erosion.—Accelerated erosion is the process brought about by man's activities on the land, thereby disturbing the equilibrium between soil building and soil removal. This kind of erosion is destructive as it removes soil particles very much faster than the formation of soils from the material underneath. The loss of the surface soil which contains most of the fertility means also the decline in crop yields. Soil erosion in the Philippines is caused mainly by water. The different kinds of accelerated soil erosion are: sheet, rill, gully, and stream bank erosion.

Sheet erosion.—This is the washing away in a more or less uniform depth, of the upper part of the soil in the croplands. It occurs when farmers cultivate their sloping lands without employing any means of controlling the flow of the surface water or runoff. At the beginning, this kind of erosion is slow and is not noticeable, but it is treacherously destructive.

Rill erosion.—This kind of erosion is the washing off of the soil by the formation of tiny incisions of a few inches depth and width which run down the slopes of an unprotected cultivated land. This is attributed to the method of planning and arranging the furrows along the slope of the land. Such rills may be erased by ordinary plowing. This type of erosion marks the beginning of the formation of more serious kinds of erosion.

Gully erosion.—This erosion occurs on paths of concentrated flow down a slope and is the cutting of deep narrow strips or gullies on the face thereof. Gullies occur both on alluvial plains as well as on uplands. On a plain where drainage

outlets are not protected, the edges of the plain are gradually eroded which consequently form into deep vertical cuts. These gullies, if not checked gradually destroy the plain. On uplands, gullying occurs mostly on slopes where runoff continually drain. This happens when farmers plow their fields up and down the slopes. Some gullies are small, but others are so big that farm animals cannot cross. Gullies grow bigger each year.

Stream bank erosion.—This kind of erosion occurs along the banks of streams and rivers. It is very destructive particularly on such lands where the substrata are of coarse or medium-textured soils. The flowing water undermines the lower part of the river or stream bank particularly along its outer curve thus causing the upper part to fall by its own weight.

FACTORS AFFECTING SOIL EROSION

Soil erosion occurs when water runs over the surface of a sloping land. This water running over the surface is called runoff. The rate of soil erosion will depend upon the speed of surface runoff. The volume of runoff as well as its speed depend upon the soil, slope, vegetation, and intensity of rainfall in the area.

SOIL

The soil possesses certain physical characteristics which influence its erodibility. Under similar conditions of climate, relief and vegetative cover, there are marked differences in the erodibility of different soils. In some cases sandy loam soils are more susceptible to erosion than clay loam soils.

Porosity and permeability are important factors in the formation of runoff. The higher the absorbing quality of the soil or infiltration of water into the soil the less runoff will be formed. Different soil types differ in porosity and permeability. Also soils rich in organic matter are porous and will absorb more water readily than those poor in it.

SLOPE

Slope has a great influence on erosion. Runoff flows faster on a steeper slope than on one with lesser grade. Taking other erosion factors equal, soil loss is greatest where runoff is fastest. Furthermore, on farm lands with the same grades of slopes, one with a longer slope will erode more than one with a shorter slope. This is so because as runoff acquires momentum its cutting power as well as the soil carrying capacity is increased considerably. A slope unprotected by vegetation or some mechanical devices to decrease the velocity of runoff suffers heavily during a heavy rainfall.

VEGETATION

The density of the vegetative cover of an area contributes a great deal to its resistance to erosion. In the heavily wooded portions of our forests the rate of soil loss is balanced by the formation of soil underneath. On cultivated farms the crops offer very little protection for the soil. Crops that can cover the ground well will give some protection for the soil but clean tilled row crops are conducive to erosion. Land on slopes exposed or bare of vegetative cover suffers heavy soil losses.

In the open areas where cogon predominates very little erosion takes place. The thick growth of cogon is quite adequate protection of the land. Even on steep slopes the grass cover if preserved and improved will give good protection.

INTENSITY OF RAINFALL

Rainfall intensity is a factor in erosion. A region with rainfall distributed throughout the year will have less soil erosion than another area where the same amount of rain occurs but only within a period of six months. In the latter area the intensity of rainfall is much bigger and hence the amount of runoff is correspondingly greater. In the former case, the intensity of rainfall is less giving more time for the water to infiltrate into the soil, hence, less runoff.

How much of the rain that falls run off the surface is shown by investigations conducted by the United States Department of Agriculture. At the Yazoo River Watershed, 27 inches of rain caused a disastrous flood, where 62 per cent of the rain water immediately ran off cultivated fields and carried soil at the rate of 34 tons per acre. Runoff from plots on barren abandoned fields was 54 per cent of the total rainfall. Surface runoff during the most intense rains increased from 75 to 95 per cent of the total precipitation. On undisturbed oak forest only 0.5 per cent of the 27 inches of rain ran off the experimental plots while soil removed was only 75 pounds per acre.

FACTORS PROMOTING SOIL EROSION

System of farming lands.—In the province, most of the farm lands are rolling and hilly. These are planted to upland rice, corn, and tobacco which are erosion promoting crops. No means of protection is employed in farming these sloping lands. Erosion is aggravated by the common farm practice of plowing up and down hill and laying the furrows along the slopes.

Crop rotation in the province is seldom practiced. Rice, tobacco and corn are planted from year to year. Sometimes the field is fallowed after the rice crop. A good rotation of crops which includes a soil building legume helps conserve the soil.

The pasture lands are over grazed. As a result, hillsides have very scant grass cover and erosion is very much in evidence.

Kaingin.—This is another factor contributing to the destruction of soil and forest. Very often *kaingin* clearings are made on steep slopes. The trees and other vegetation are burned, leaving the area cleared and entirely bare. When it rains runoff rushes downhill and generates quite a tremendous cutting power that detaches and carries a great deal of surface soil. Rills and sometimes gullies often result after one heavy rain.

SOIL EROSION SURVEY METHODS

The primary purpose of the soil erosion survey is to determine the degree of erosion in the different soils of the province, that is, the extent to which removal of the surface or subsoil has progressed as well as the amount of gullying with special reference to its effect on the cultivation of the land.

The present depths of the different soil types under cultivation in the province were compared to the depths of the virgin soils or soils with normal profiles. The depths of different soils under normal profiles were established after various determinations over a wide area by boring with the soil auger, studying road cuts, pits, open wells, and stream banks.

Variations in the depth of soil as caused by erosion together with the presence of gullies are considered in mapping the different erosion classes. The depth and frequency of occur-

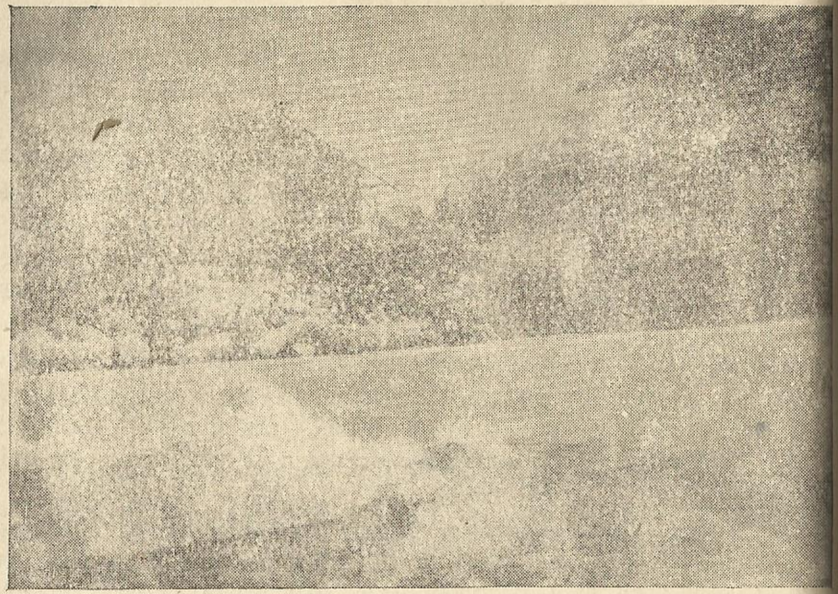


Figure 22. While gathering of firewood is essential in flue-curing of Virginia tobacco, it brings about forest or vegetative cover denudation and soil erosion.

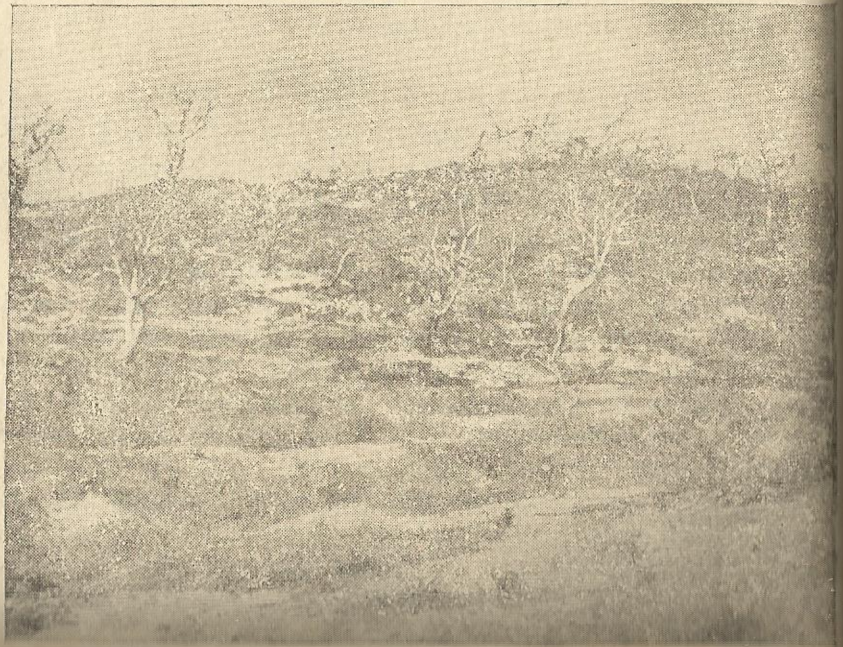


Figure 23. *Kaingin* in no small measure contributes to soil erosion and denudation of the forest of the province.

rence of gullies are noted as these affect the cultivation of the land. The classification of the different degrees of soil erosion used in this survey are as follows:

Erosion Class	*Degree of erosion*	*Description*
0	No apparent erosion; no gullies	No apparent erosion; no gullies.
1	Slight erosion	Less than ¼ of original surface soil eroded; occasional crossable gullies present.
2	Moderate erosion	From ¼ to ¾ of original surface soil eroded.
3	Severe erosion	From ¾ of original surface soil to ¼ of subsoil eroded.
4	Very severe erosion	All of the surface soil to ¾ of subsoil eroded.
5	Excessive erosion	All of the surface soil and over ¾ of subsoil eroded.
W	Normal erosion	Balance between soil erosion and soil formation is maintained.
Q	Erosion, undifferentiated	Erosion conditions change as often as floods occur.

The extent as well as the degree of soil erosion will increase each year unless control measures are instituted and practiced.

SOIL EROSION IN THE DIFFERENT AREAS

The soils of Ilocos Norte Province have undergone erosion, normal or geologic and accelerated, at one time or another. The erosion survey of the province was conducted to determine the degree of erosion to which the different soil types have been subjected. However, due to the numerous factors responsible for erosion accurate erosion losses by individual fields cannot be presented but rather the general distribution of such losses. So much so that one can expect that the same soil type in different areas may have different degrees of erosion, or two different but adjacent soil types may have the same degree of erosion. Likewise, different adjacent soil types may have different degrees of erosion and one soil type in an area may have different degrees of erosion within its boundaries.

The degrees of erosion to which the different soil types of the province have been subjected are shown in table 10.

TABLE 10.—*Erosion classification of the different soil and miscellaneous land types of Ilocos Norte.*

Erosion class	0–No apparent erosion	1–Slight erosion	2–Moderate erosion	3–Severe erosion	4–Very severe erosion	5–Excessive erosion	W–Normal erosion	Unclassified
Relief	Level, nearly level to gently undulating	Undulating, gently rolling to hilly	Rolling to hilly	Rolling, hilly and mountainous	Hilly to mountainous	Hilly	Nearly level, rolling, hilly and mountainous	
Present land-use	Row crops	Row crops; second growth forest; grass; betel palm	Row crops; maguey; betel palm; second growth forest; grass	Grass; second growth forest; shrubs	Grass; second growth forest; shrubs	Grass and shrubs	Wildlife; primary forest; shrubs; grass	
Soil type	228–Bantog clay 16–Bantog clay loam 389–Bantog sandy loam 390–Bantog silt loam 870–Bantog silty clay 391–Bantog silty clay loam 108–Bolinao clay loam 558–Bolinao loam 383–Maligaya silty clay loam 68–San Fernando clay 67–San Fernando clay loam 871–San Fernando sandy loam 868–San Fernando silty clay 236–San Manuel clay loam [illegible]–San Manuel loam 97–San Manuel sand 596–San Manuel sandy clay loam 96–San Manuel sandy loam 82–San Manuel silt loam 869–San Manuel silty clay 94–San Manuel silty clay loam 168–Umingan clay loam 322–Umingan loam 100–Umingan sandy loam 872–Umingan silty clay loam	98–Annam clay loam 259–Bantay clay loam 108–Bolinao clay loam 729–Cervantes clay loam 422–Faraon clay loam 140–Luisiana clay loam 867–Tadao sandy clay loam	98–Annam clay loam 259–Bantay clay loam 170–Bantay loam 153–Bolinao clay 108–Bolinao clay loam 558–Bolinao loam 729–Cervantes clay loam 422–Faraon clay loam 867–Tadao sandy clay loam	259–Bantay clay loam 108–Bolinao clay loam 729–Cervantes clay loam 422–Faraon clay loam	259–Bantay clay loam 108–Bolinao clay loam 729–Cervantes clay loam	259–Bantay clay loam 422–Faraon clay loam	140–Luisiana clay loam 594–Dune land 45–Mountain soils, undifferentiated 152–Riverwash 599–Rock land 595–Sand and coral bed	Badoc Island

To supplement table 10 the localities where the soils were mapped are listed below.

Bantog clay (228).—This soil type is found in Alabaan, Marcos, along the Dingras-Banna road; east of Batac town proper; Payac-Quiom-Sumader Valley, Batac; on the plain along the Batac-Badoc road; and, in the vicinity of Badoc from Pagsanahan in the west to as far as Cotor, southeast of the town.

Bantog clay loam (16).—This soil type is found southwest of Batac extending to as far as Bo. Mabaleng, south of the town; south of San Nicolas; and, west of Dingras–Banna road.

Bantog sandy loam (389).—The area along the Laoag–Paoay provincial road at the junction of the road to Bo. Calayab was classified under this soil type.

Bantog silt loam (390).—This soil type is found and mapped west of Badoc and in Catuguing, San Nicolas.

Bantog silty clay (870).—This soil type was mapped in Santa Cruz, Badoc, and Capariaan, Marcos.

Bantog silty clay loam (391).—This soil type was mapped as small patches of level areas in-between rolling and hilly areas on the southwestern portion of the province.

Bolinao clay loam (108).—This soil type was mapped between Burgos and Pasuquin and in Currimao. The nearly level areas in Currimao and east of the road from Caruan to Tulnagan, Pasuquin, are not apparently eroded. The undulating to rolling areas are slightly eroded while the rolling to hilly areas are moderately to severely eroded.

Bolinao loam (558).—The nearly level to undulating area east of the road between Diriqui, Pasuquin, and Bayog, Burgos; the nearly level area in Barat, Burgos, and the undulating to rolling area in Burgos extending toward the east up to Baruyen were classified under this soil type. There is no apparent erosion on the nearly level areas. The undulating portion is slightly eroded while the rolling area is moderately eroded.

Maligaya silty clay loam (383).—The patches of level area in the municipalities of Banna and Nueva Era and the level area northeast of the Banna–Nueva Era road bordering Umingan silty clay loam and Cervantes clay loam were mapped under this soil type.

San Fernando clay (68).—This soil type is found in the plains of Paoay, Batac, Laoag, Sarrat, Piddig and Curarig, Bacarra.

San Fernando clay loam (67).—This soil type was mapped in Biding, Marcos; Baruyen, Bangui and Vintar.

San Fernando sandy loam (871).—This soil type is found about a kilometer north of Pasuquin town proper covering the barrios of Nalba, Nalbacan, Sulbec, Nagsanga and Santo Domingo.

San Fernando silty clay (868).—The level areas in Bos. Barabar and San Antonio, San Nicolas, were classified under this soil type.

San Manuel clay loam (236).—This soil type is found in the vicinity of Batac; in the Subec-Lusong-Burayoc area and Caunayan, Pagudpud; south of Pagudpud; and, in the small patch of level land on the Ilocos Norte–Ilocos Sur provincial boundary.

San Manuel loam (190).—This soil type is found in the plains of Badoc, Dingras, Sarrat, San Nicolas, Laoag, Paoay, Batac, and Pagudpud along the courses of rivers and creeks.

San Manuel sand (97).—A thin strip of land from Calloet, Bacarra, to Puyopuyan, Pasuquin, bordering the dune land was mapped under this soil type.

San Manuel sandy clay loam (596).—This soil type is found in the vicinity of Pasuquin town proper and Pasnga, Bacarra.

San Manuel sandy loam (96).—This soil type was mapped as an irregular strip of land from Caruan, Pasuquin, to Casili, Laoag; Balacad to Cavit, Laoag; Bacsil, Paoay, and west of Paoay town proper.

San Manuel silt loam (82).—The Lagsada–Nagrebcan–Paciencia area; a portion of the Dingras–Solsona valley; a small patch of level area in Sumader, Batac, east of the road to Quiom; and, a small area in San Manuel, Sarrat, between San Fernando clay and the river, were mapped under this soil type.

San Manuel silty clay (869).—This soil type was mapped in Dingras; Laoag; Bacarra; and, Sumgar, Batac.

San Manuel silty clay loam (94).—This soil type is found in the vicinities of Batac.

Umingan clay loam (168).—This soil type is found in the Abucay–Gayamat area, Piddig; Pasaleng, Pagudpud; and in Balaycali, Dingras, to Nagpatpatan, Solsona.

Umingan loam (322).—The Lanao–Dampig plain, Bangui; some parts of the Dingras–Marcos–Banna–Solsona–Piddig valley and patches of level area between hills in Cabayo, Nagsabaran, Lipay, Bago, and Ditolong, Vintar, were mapped under this soil type.

Umingan sandy loam (100).—This soil type is found in the municipal district of Adams and in Sta. Maria, Piddig.

Umingan silty clay loam (872).—This soil type was mapped in Tabtabagan–Bugasi–Balioeg–Lading area, Banna.

Annam clay loam (98).—The rolling to hilly area fringing the China Sea northeast of Pagudpud and the small hill at the road junction of Pagudpud town proper were classified under this soil type. The greater portion of the area is slightly eroded and the rest are moderately eroded.

Bantay clay loam (259).—This soil type was mapped on the southwestern part of the province extending to as far as Pasuquin. Erosion on this soil type is generally moderate to excessive due to the continuous cutting of trees used for flue-curing Virginia tobacco. The strip of gently rolling to rolling land from Bungro to Sacritan, Pinili, is slightly eroded.

Bantay loam (170).—This soil type was mapped on the rolling land within the municipalities of Vintar and Bacarra and Laoag City; east of Bacarra–Pasuquin road fringing the coastal plain and south of Narusodan, Badoc. Erosion on this soil type is moderate.

Bolinao clay (153).—This soil type was mapped west of Badoc. It is moderately eroded.

Cervantes clay loam (729).—This soil type occupies the eastern part of the province adjoining the mountainous area from Uguis, Nueva Era, to Paddaggan, Burgos. The area has been subjected to soil erosion varying from slight to very severe.

Faraon clay loam (422).—This soil type starts from the east of Uguis, Nueva Era, to the east of So. Tumedtedted, Batac. The area is slightly to excessively eroded.

Luisiana clay loam (140).—The rolling, hilly and mountainous area south of Pasaleng, Pagudpud, extending towards the municipal district of Adams was classified under this soil type. The surrounding area of Adams is slightly eroded. The rest of the area is thickly forested. Therefore, soil erosion is normal.

Tadao sandy clay loam (867).—The irregular strip of undulating to roughly rolling area from the north of Sacay, Pasuquin, to Alaoa-ao and Dayas, Bangui, was mapped under this soil type. Part of this soil type is slightly eroded, the rest are moderately eroded.

Dune land (594).—This land type was mapped along the coast of the province from the north of Baruyen, Bangui; from Danao to Agabang, Bangui; from Estancia, Pasuqin, to Pangil, Currimao; and from Sucod to the river south of Gabut, Badoc. Erosion was classified as normal.

Mountain soils, undifferentiated (45).—This land type covers the eastern portion, extending from the southernmost tip to the northern coast of the province. Erosion was classified as normal.

Riverwash (152).—This land type is found along the courses of streams, the most prominent of which are along the Laoag and Bacarra River banks. Erosion was classified as normal.

Rock land (599).—As its name implies this land type occupies the rocky area on the northwestern part of the province from Similla, Pasuquin, to the coast, and in Nagsurot, Burgos, and a small area in La Paz, Laoag. Erosion was classified as normal.

Sand and coral bed (595).—This land type is found along the coast bordering the road from Caruan, Pasuquin, to Bayog, Burgos; and from Buraan to Cabarabaan, Burgos. Erosion was classified as normal.

Unclassified area.—The island of Badoc was not surveyed due to lack of transportation facilities.

EFFECTS OF SOIL EROSION

Soil erosion has an exhausting influence on agriculture. Previously, most of us have had so little concern about its adverse effects; it was only recently that we became aware of the fact that erosion if left uncontrolled will eventually deplete our agricultural lands of their productivity thereby affecting the nation's economic stability and prosperity.

PHYSICAL EFFECTS

Where erosion exists, the first to suffer is the land which is gradually robbed of its surface soil or furrow slice. This means that not only the inherent fertility of the soil is lost but costly commercial fertilizers added are wasted as well. Much more, if the furrow slice shall be comprised less of the surface soil and more of the subsoil which is usually less fertile, there will be greater difficulty in maintaining a satisfactory physical condition of the soil. Moreover, eroded soil materials, such as sand and gravel, have at times covered entire fields of newly cultivated crops causing so much loss in seeding and interference in subsequent cultivation. The objectives of any scheme of soil management, however good, is therefore seriously interfered with. One appreciable effect of soil erosion is the silting up of reservoirs which reduces their storage capacity and adding greatly to the expense of their upkeep. Gullying and stream bank cutting of agricultural lands seriously impair the productive capacity of the farm and the farmer's income suffers an appreciable loss. Likewise, highways near or parallel to stream or river courses suffer from stream bank cutting and those along the hills and mountains suffer from landslides thereby the means of transportation is seriously impeded.

ECONOMIC AND CULTURAL EFFECT

The adverse effects of accelerated or man-made soil erosion are much too obvious that they need not be over emphasized. Unfortunately, however, most people take the existence of soil for granted, in the manner that almost everyone always indifferently regards the existence of the air we breath. Whereas our supply of the latter has never been doubted, the certainty of our enjoying the bounty of the former cannot last forever unless we recognize the imminent dangers of soil erosion.

Soil conditions have much to do to shape the pattern of a nation's existence. While we begin by trying to analyze their effects from an agricultural point of view, we ultimately arrive to their economic and social effects as well. This is so because agricultural, economic and social conditions are closely interrelated so much so that it is quite difficult to separate them too sharply. Erodibility being one of many soil conditions, should ever be borne in mind as much as fertility.

We know that food, shelter, and clothing, man's basic needs, all emanate from the soil. Soil lost to us if taken in terms of the economic value of production of these basic needs surely would amount to enormous figures. The high cost of living may then be partially understood.

We know that while soil loss mounts, there is no sign that population also declines. The tendency is when population increases, people tend to overwork the soil. Overworking the soil inevitably results in decline of productivity. Soil erosion then commences and if unchecked, the people simply abandon the affected area and move to other places. This may happen once or more than once within a generation. What has started as an agricultural problem also becomes an economic and social problem.

We know that industry, especially the manufacture of consumer goods, is dependent on the supply of various raw materials. By and large, these raw materials are produced from the soil. Industry, therefore, directly and indirectly is affected by soil erosion. In turn when factories shut down or curtail operations, men lose their jobs and another social problem is added.

Soil erosion, therefore, is not the individual farmer's problem alone. While it affects his capacity to provide for his family's wants and meet his social obligations, erosion eventually becomes a community's, a province's and finally a nation's agricultural, economic, and social concern.

METHODS OF EROSION CONTROL

There are two general ways of erosion control in croplands; namely, (1) vegetative measures, and (2) mechanical means. Vegetative measures are simpler and easier to apply, while mechanical means usually require engineering aids, tools, and machinery. The former is usually employed on land that are nearly level to gently rolling, while the latter is adapted to rolling and undulating land. Sometimes both means are employed simultaneously, or one in support of the other depending upon attendant circumstances.

VEGETATIVE MEASURES

Control of erosion by vegetative means deals with the use of plants following the normal farm operations and use of ordinary implements and machinery.

Cover cropping.—Vegetative cover is the first protection against runoff and erosion. Cover crops are usually planted after the harvest of row tilled or seasonal crops. There are also permanent cover crops which are mostly planted in orchards. When planting cover crops mulches of dead stems, leaves, or straw are necessary since cover crops offer protection only after they have attained considerable growth.

Strip cropping.—This vegetative method of erosion control is the alternate cultivation of clean tilled crops on one strip and dense close growing crops on the next strip. These alternate strips break up a relatively large sloping field into small narrow bands lying across the slope. They serve to check the momentum of runoff and to filter out the soil particles. The subsequent loss of the speed of runoff allows rain water to seep into the soil rather than readily flow down the slope. Soil and water are thus conserved.

Buffer strip cropping.—Buffer strips are established bands usually on the contour, two or three meters wide, planted to perennial grass or other erosion-resisting vegetation. They are arranged in regular alternation with relatively wider strips of row tilled crops. Buffer strips are adapted to land with slopes up to eight per cent. When the slope is long, a combination of vegetative and some mechanical means may be necessary. Grasses such as Guinea grass, Napier, Brown-top, Bermuda grass, and *Ipil-ipil* (periodically trimmed to about a foot high) are recommended.

Grassed waterways.—Waterways in soils work are either natural or man-made depressions on sloping areas which serve as passageways for water that goes through a farm from adjacent land or accumulating on it due to rain. They are important in any scheme of soil and water conservation. Naturally located depressions serve the purpose best. Man-made canals strategically laid are also necessary for more efficient discharge of runoff. The establishment of a dense vegetative cover over all waterways is imperative. Grasses readily adaptable to the area should be used, but whenever practicable those species which form a dense turf are preferable. Inasmuch as waterways are supposed to carry heavy flows during certain periods they should be designed to handle maximum runoff from the heaviest rainfall occurring in the locality once

in about eight to ten years. Grassed waterways are essential wherever excess runoff accumulate such as in strip cropped fields.

MECHANICAL MEASURES

On steep slopes vegetative measures offer inadequate protection for the soil. Mechanical means of erosion control are therefore essential in conjunction with the vegetative phase.

Contour tillage.—Contour tillage is plowing and planting on the contour. This is an erosion control measure which is most effective on two to eight per cent slopes and less than 100 meters long. Ridges formed by the tillage implements retard the downhill flow of water. These ridges serve adequately when rainfall are intense or heavy. Contouring is not enough protection especially when slopes are not uniform and above eight per cent, when the fields are already eroded, or when subsoils are clayey and compact. In these cases excess runoff may break through the ridges thus necessitating the adoption of other mechanical conservation measures like terracing.

Terracing.—Terraces are mechanical measures of soil conservation and are differentiated into three types; namely, (1) absorptive, (2) bench, and (3) drainage.

Absorptive terrace or ridge type is designed for moisture conservation. It is adapted to gentler slopes and absorptive soils.

Bench terrace is constructed on the contour. It has a steep drop and adapted to steeper slopes.

Drainage terrace or broad channel type is designed to conduct water from a field at low velocity.

As used in this text, terrace may denote a ridge type or a combination of ridge and channel type.

Terraces are built across a slope. They are either level or graded depending upon the purpose for which they are made. Graded terraces lead runoff from the field at nonerosive velocities. Level terraces impound most of the water giving it time to soak into the soil. Where the average annual rainfall is less than 30 inches, level terraces are recommended. Dimensions of terraces are also of utmost importance. They should be large enough to avoid overtopping. Usually the runoff which may be expected from the heaviest rain occurring on an average of once in 10 years is used as a basis. Their shape is generally based on the farming equipment used.

Terrace construction requires technical skill, financing, and special implements and machinery. Aside from these considerations, one must realize that all slopes and all soils cannot be successfully or economically terraced. Sandy, stony, and shallow soils, fields dotted by humps or mounds, or slopes that change planes and steepness every 30 meters are impractical to build terraces on.

Diversion ditches.—Diversion ditches or diversion terraces are built to intercept the runoff from drainage areas. They are usually larger than field terraces. They are designed to protect cultivated fields from hillside runoff by providing for a passageway of the water away from the fields to other nearby areas where it is spread or dispersed. Where adjacent slopes generate runoff towards a terraced area, diversion ditches carry the water away from the terrace system, or if towards a gully diverting the water assist in controlling its further enlargement.

OTHER ASPECTS OF EROSION CONTROL

Whereas erosion depletes the soil of its inherent fertility, low fertility also brings about soil erosion. Infertile soils invariably mean poor vegetation, thus more surface soil is exposed to direct rain and wind action Therefore, soils of low fertility when tilled are highly erodible. In this case proper and adequate fertilization can minimize erosion.

The regular application of farm manures and the practice of green manuring increase the soil's organic matter content. Organic matter, aside from enhancing soil fertility, also improves tilth and maintain if not improve soil structure. Stable and favorable soil structure means higher porosity and better permeability. When soils are porous and permeable plant root penetration is improved. All of these favorable physical conditions when attained promote the soil's water absorbing and water holding capacities or in other words surface runoff is minimized.

Crop rotation should essentially be a part of every farm program. A well planned scheme of crop rotation, aside from providing a practical means of utilizing green manures and fertilizers, counteracting possible development of toxic substances, and improving crop quality and increasing yields, also

minimize or help control erosion. This farm practice keeps the soil in suitable physical condition, helps maintain the supply of organic matter and nitrogen in the soil, provides vegetative cover, and changes the location of the feeding ranges of roots.

The physical effects of liming such as the promotion of soil granulation of fine textured soils and the modification and improvement of the structure of coarse textured soils thus making them lighter to work subsequently contribute much to erosion control.

An efficient system of soil management in support to vegetative and mechanical measures is, indeed, necessary to combat soil erosion. The different practices followed or adopted should form a farm program that as a unit could fit the kind of soil or kinds of soils within a farm so that the end attained is the combined beneficial effects of the many interacting processes involved. Each farmer, therefore, should first appraise the erosion hazards of his farm, then plan a cropping system and supporting conservation practices to reduce or offset the erosion hazards.

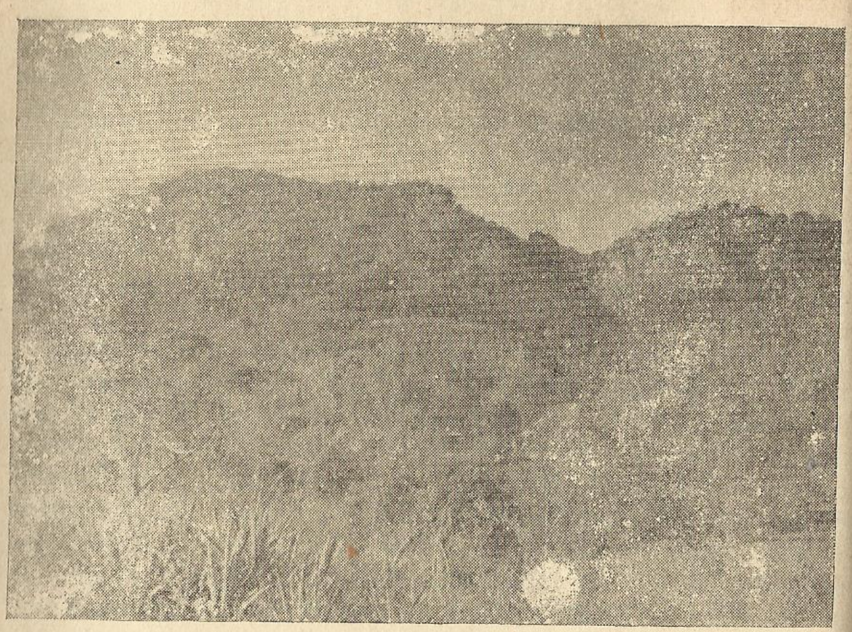


Figure 24. Sumiling Reforestation Project, Sarrat, Ilocos Norte. Denuded hillside is classified as Bantay clay loam under erosion class 3.

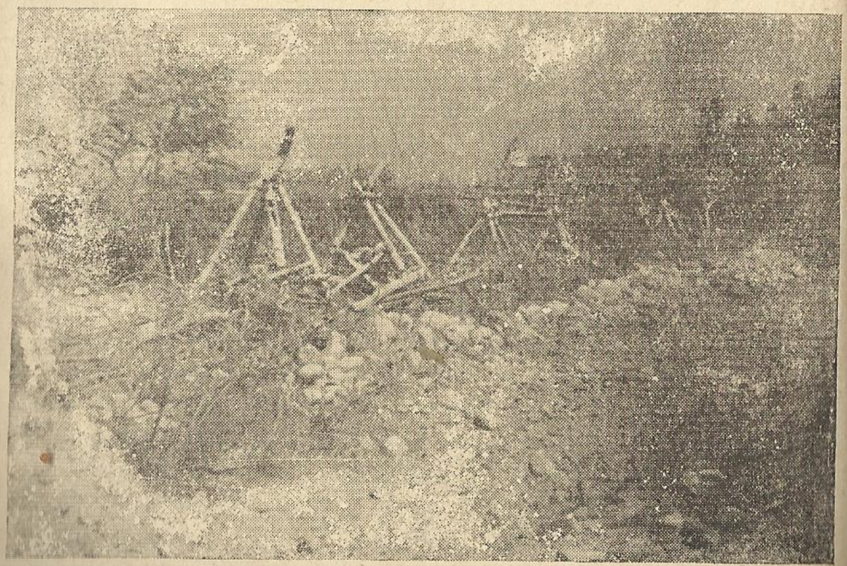


Figure 25. An effective control measure for stream bank cutting commonly practiced in several towns of Ilocos Norte.

CHEMICAL CHARACTERISTICS AND LIME AND FERTILIZER REQUIREMENTS OF THE SOILS OF ILOCOS NORTE PROVINCE

By Ignacio E. Villanueva [1]

The study of the chemical nature of the soils of Ilocos Norte is fundamental. From this laboratory investigation it is important to know the soil reaction (pH), amount of nutrient elements available to plants, the lime and fertilizer requirements of the soil for crops to be grown.

The elements considered essential in the growth processes in plants are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and iron. The first four come from the air and water. The major elements which are needed by plants in large quantities like phosphorus, potassium, calcium, magnesium, and sulfur as well as the minor or trace elements which are needed in very small amounts like iron, manganese, boron, copper, zinc, and molybdenum, are derived from the soil. There are other elements like chlorine, sodium, and silicon as mentioned in literature that affect plant growth, although they are considered not very absolutely essential. The three major elements, nitrogen, phosphorus and potassium, are the basic components of a complete fertilizer mixture, as these elements are generally critical in the soil due to crop removal, runoff or seepage and fixation in the soil. In non-calcareous soils, the elements calcium and magnesium, are generally inadequate and render the soil acidic, sometimes causing apparent calcium and/or magnesium deficiencies in plants. Manganese, iron, boron, copper, zinc, and molybdenum are needed by the plants but only in minute quantities. Absence of these elements or presence in excessive amounts affects the quality and quantity of crop yield or gives toxic effect to plants. Deficiencies of these elements be it major or trace elements especially those derived from the soil are due to continuous cropping, tillage, erosion, and leaching.

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Our farmers in order to obtain higher yields and better profits from their crop lands are advised to apply organic and commercial fertilizers, composts, manures and agricultural lime not only to correct acidity, adjust the nutritional deficiencies of the plants but also to increase the yield and produce better quality products. Modern fertilizer mixers abroad are now incorporating the trace elements like copper, zinc, and molybdenum to produce healthy and vigorous plants. The nitrogen deficiency may be corrected by the addition of animal and green manures or commercial nitrogenous fertilizers like ammonium sulfate, urea, and other nitrogenous sources. Superphosphate, guano, and other phosphatic fertilizers will check phosphorus deficiency. For potash deficiency, the application of the commercial potassic fertilizer like potassium sulfate or muriate of potash, is very necessary. Our local waste materials such as wood ash, rice hull ash, coconut ash, are considered good sources of potassium. The calcium and magnesium deficiencies of our soils may be corrected by the application of agricultural lime or dolomitic limestone. Lime, besides furnishing available calcium, corrects acidity, provides a better medium for cation and anion exchange and encourages microbial activities in the soil.

METHOD OF CHEMICAL ANALYSIS

In order to be able to determine crop responses in the soil, samples of the soil have to be analyzed in the soils laboratory to determine the relative and very critical presence or absence of the available nutrients essential to plant growth. The degree of availability of these nutrient elements indicates also the degree of crop response. In other words, it serves as an index of the fertility of the soil.

Soil samples submitted for analysis are first air dried, pulverized with a wooden mallet and then passed through a 2-mm. sieve and thoroughly mixed. The soil reaction (pH) or hydrogen ion concentration of the soil is determined by a precision equipment called Beckman Model H–2 potentiometer fitted with a glass electrode. For the determination of ammonia and nitrates the Spurway method was followed. The available phosphorus in the soil was determined by the Truog method while the elements potassium, calcium, iron, magnesium and manganese were determined by the Peech and English method employing the Leitz photo-electric colorimeter provided

with suitable light filters. However, for total nitrogen, the method of analysis of the Association of Official Agricultural Chemists of the United States was followed and for the determination of organic matter, the Walkley and Black method was used.

INTERPRETATION OF THE RESULTS OF CHEMICAL TESTS

Soil reaction or pH value.—Soil reaction of the soil denotes the degree of acidity or alkalinity, usually noted with the symbol pH. The range of the scale is from 1 to 14. A reading of the scale at 7 is neutral; at 6, slightly acid; at 8, slightly alkaline. The behavior and availability of the plant nutrient elements as well as the toxic elements found in the soil are affected by it. Hence, it becomes a limiting factor in plant growth and reproduction. It will be noted in the Truog's modified version of Pettinger's chart that iron and manganese, aluminum, boron, copper, and zinc are relatively high in acidic concentrations. Since these elements are soluble and available at strongly acidic concentrations, they become toxic to plants. Yet at high pH or slightly alkaline conditions these elements become unavailable to plants thereby causing abnormal growth. The elements nitrogen, phosphorus, potassium, sulfur, calcium and magnesium are generally less available to plants at low pH or at very strong or high acidity. For a thorough understanding of the availability and behavior of nutrient elements, the chart is reproduced here. This chart shows the general trend of the relation of soil reaction to the availability of plant nutrient elements. Truog's explanation of the chart follows: "The influence of reaction on availability of each nutrient element is expressed by the width of the band (the wider the band, the more favorable the influence) carrying the name of the respective element. Thus, for the maintenance of a satisfactory supply of available nitrogen for example, a reaction or pH range of 6 to 8 is the most favorable. This does not mean that if the reaction of a soil falls within this range, a satisfactory supply of nitrogen is assured. All it means is that so far as reaction is concerned, the conditions are favorable for a satisfactory supply of this element in available form. Also the narrowed band for nitrogen at pH 5 does not necessarily mean that a deficiency of this element will prevail at that pH; it means that so far as reaction is concerned, the conditions are not favorable for an abundant

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supply in available form. Factors other than soil reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply."

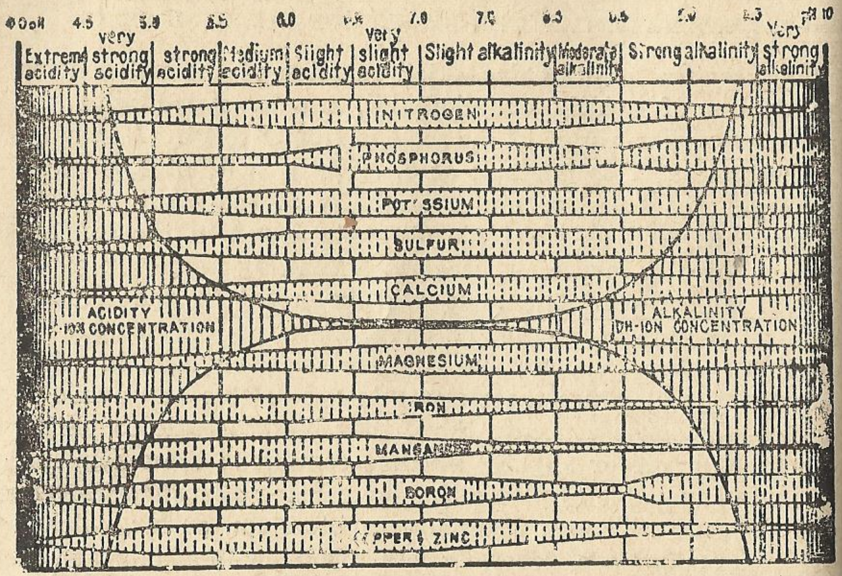

Fig. 25. Chart showing general trend of relation of reaction to availability of plant nutrients.

It is shown in table 11 that different plants have different optimum soil reaction requirements or pH preferences and different tolerance limits. Also in the table, plants like rice, pineapple and tobacco prefer medium acid soils (pH 5.5 to 6.1) while alfalfa, sugar cane and oranges prefer slightly acid to slightly alkaline reaction (pH 6.2 to 7.8). The tolerance limits of the former group of plants were estimated at pH 4.8 to 6.9 while those of the latter, at pH 5.5 to 8.5. Some plants like tomato and corn tolerate a wide pH range (pH 4.8 to 8.5) although the best growth of the plants were obtained between pH 6.2 and 7.0.

The surface soils of Ilocos Norte Province were analyzed in the soils laboratory branch at Vigan, Ilocos Sur, and they are presented in table 12. There were originally 113 soil samples gathered but only 33 composite soil samples representing the soil types of the province were submitted for mech-

TABLE 11.—*The pH requirements of some economic plants.*

Plant	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 textilis* Nee[1]	Y	X	X	X	Y	O
Banana, *Musa sapientum Linn*[1]	Y	X	X	X	Y	O
Caimito, *Chrysophyllum caimito Linn*[1]	Y	X	X	Y	O	O
Cassava, *Manibot esculenta Crantz*	Y	X	X	X	Y	Y
Coffee, *Coffea arabica Linn*[1]	Y	X	X	Y	O	O
Corn, *Zea mays Linn*[2]	Y	Y	X	X	Y	Y
Cowpea, *Vigna sinensis (Linn) Savi*[2]	Y	Y	X	Y	Y	—
Durian, *Durio zibethinus Linn*[1]	Y	X	X	Y	O	O
Onion, *Allium cepa Linn*[2]	O	Y	X	Y	Y	Y
Orange, *Citrus aurentium Linn*[3]	—	Y	X	X	X	Y
Peanut, *Arachis hypogaea* Linn[2]	Y	Y	X	X	Y	—
Petsai, *Brassica chinensis* Linn[4]	Y	Y	X	X	X	X
Pineapple, *Ananas comosus* (Linn)	Y	X	Y	O	O	O
Rice, *Oryza sativa* Linn[1]	Y	X	X	Y	Y	O
Soybean, *Glycine max* (Linn) Merr.[2]	Y	X	X	X	Y	Y
Sugar cane, *Saccharum officinarum* Linn[2]	O	Y	X	X	X	Y
Sweet potato, *Ipomoea batatas* (Linn) Poir[1]	Y	X	X	Y	O	O
Tobacco, *Nicotiana tabacum* Linn[2]	Y	X	Y	O	O	O
Tomato, *Lycopersicum esculentum* Willd.[2]	Y	Y	X	X	Y	Y

Legend:

X—most favorable reaction

Y—reaction of which plants grow fairly well or normally.

O—unfavorable reaction

[1] Based from the soil reactions where they are grown with the productivity ratings of the soil types in 11 provinces. A pH range of 5.7 to 6.2 was found to be 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, Phosphorus and Iron Content" *Philippine Agriculturist*, 33: 120–125. (1949).

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

[3] From C. H. Spurway, "Soil Reaction (pH) Preferences of Plants, "*Mich. Agr. Expt. Sta. Sp. Bull. 306.* (1941). Optimum range given was pH 6.0 to 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 at pH 4.2 to 8.6; optimum range was pH 5.9 to 8.6.

anical and chemical analyses. The table shows a pH range of 3.8 to 7.1. Sample No. 57 collected from Adams Municipal District and classified as Luisiana clay loam gave a pH of 3.8.

Nitrogen.—Nitrogen is one of the three major plant nutrients that plays a vital role in the physiological and metabolic processes in plant and animal life. The nitrogen compounds comprise 40% to 50% of the dry matter of protoplasm, the living substance of plant cells. Appreciable and normal growth is impossible unless an adequate supply of this element is provided to plants. The green coloring matter of leaves called chlorophyll contains nitrogen compounds. The nitrogen compounds are very mobile in plants, readily available to growing points and to other plant parts which are in need of such compounds.

TABLE 12.—*Chemical analysis of the different soil types of Ilocos Norte.*

Soil type	pH value	Available constituents in parts per million (p.p.m.)							
		Ammonia (NH_3)	Nitrate (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe)
Annam clay loam	5.0	2	10	2	191	4,100	960	19	9
Bantay clay loam	5.8	10	10	9	164	6,240	1,360	40	3
Bantay loam	5.5	2	T	2	151	6,600	1,325	25	1
Bantog clay	5.6	2	5	3	136	6,100	2,510	34	8
Bantog clay loam	6.2	10	10	3	145	5,400	1,780	40	6
Bantog sandy loam	5.1	2	2	2	120	900	630	86	1
Bantog silt loam	5.0	2	2	5	146	4,300	1,350	74	4
Bantog silty clay	5.5	2	10	4	175	6,900	1,190	25	2
Bantog silty clay loam	7.1	10	T	2	164	16,900	1,290	82	2
Bolinao clay	4.7	2	T	5	153	5,200	3,750	64	2
Bolinao clay loam	6.0	2	T	6	153	6,100	1,000	33	2
Bolinao loam	5.3	2	10	2	149	3,200	1,100	22	4
Cervantes clay loam	4.5	2	T	5	200	1,800	3,750	56	3
Faraon clay loam	6.3	2	T	5	177	6,200	1,450	28	1
Luisiana clay loam	3.8	2	5	2	126	1,000	140	10	44
Maligaya silty clay loam	5.7	2	10	2	148	5,700	1,960	57	18
San Fernando clay	6.6	2	5	2	146	7,900	1,100	52	7
San Fernando clay loam	6.3	2	5	4	130	6,300	1,240	46	5
San Fernando sandy loam	7.1	10	5	2	132	4,400	4,750	28	2
San Fernando silty clay	5.1	10	5	1	120	4,800	1,200	48	2
San Manuel clay loam	5.9	2	5	2	123	5,400	2,080	42	24
San Manuel loam	5.4	2	5	4	143	5,300	1,660	32	14
San Manuel sand	6.3	2	T	2	94	6,600	430	10	8
San Manuel sandy clay loam	5.3	2	T	2	115	4,100	1,270	30	13
San Manuel sandy loam	5.5	2	10	3	119	3,200	1,170	40	15
San Manuel silt loam	5.2	2	10	6	125	4,600	1,450	142	25
San Manuel silty clay	5.9	2	5	3	122	5,900	1,372	44	5
San Manuel silty clay loam	7.0	2	2	1	167	9,000	1,500	82	4
Tadao sandy clay loam	4.0	2	T	1	143	900	400	48	5
Umingan clay loam	4.5	2	10	2	96	3,400	630	32	121
Umingan loam	5.5	2	5	5	101	5,000	1,050	29	28
Umingan sandy loam	4.0	2	10	2	188	300	200	19	21
Umingan silty clay loam	4.0	25	10	2	126	2,100	1,500	28	136

Deficiency of this element has a very marked effect on the yield of a crop. The plants usually exhibit a characteristic symptom, the yellowing of the leaves, relatively due to very little chlorophyll.

Ammonia and nitrates.—In view of the tediousness and time element involved in getting the result for total nitrogen employing the general soil testing methods the rapid method is followed. Besides, total nitrogen cannot give a direct and positive correlation with crop yield. It must be remembered that the forms of nitrogen in the soil are nitrate nitrogen, ammonia nitrogen, and the organic form. As to whether the nitrate nitrogen or the ammonia nitrogen is preferred in plant nutrition, literature on the subject is still desired. It is enlightening to note that the pH of the soil affects the nutrient uptake. In very strongly alkaline reaction, the nitrate-ion is preferred because the ammonia compounds can be transformed into free ammonia (NH_3) which is injurious to plants. In very strongly acid reaction, the nitrate-ion is preferred because the plasma behaves like a weak base and thereby attracts the negatively charged nitrate-ion. In dry regions the nitrate (NO_3) form is preferred to the ammonia form. It has been reported also in the rice culture that ammonium fertilizers proved to be more superior to nitrate fertilizers, as ammonia is rapidly transformed into nitrate by micro-organisms. Plants normally assimilate nitrogen in the nitrate form; the grass family also absorb ammonia form as well. Nitrate nitrogen is the most soluble and organic nitrogen is the least soluble. Since both forms are water soluble they are easily lost by leaching. The ammonium form however, can be fixed in the soil.

Phosphorus.—This element is just as important as nitrogen. It has its vital role in metabolism. It is a constituent of vital compounds such as phytins, lecithins and nucleotides besides being present in the majority of enzymes known. Also it plays an important role in the transformation of energy and in fat metabolism. In crops, it affects both growth and reproduction. It stimulates root development and hastens maturity, counteracts the excessive effect of nitrogen in grain crops, sugar cane and non-leafy vegetables.

Due to phosphate deficiency in soils, very marked symptoms occur in plants. The root system is undeveloped. The leaves are often small, reddish-brown, purple or bronze-like in color. Fruits remain very small and therefore, crop yields are low and of poor quality. An acute shortage of phosphorus retards flowering and ripening of fruits, seed formation, emergence of corn silk; increases acidity of fruits; results in low sucrose content of sugar cane and starch formation in root crops.

An excess of phosphorus, while it can accelerate the ripening of fruits at the expense of vegetative growth, sometimes could bring about the deficiency of some elements. For instance, it has been reported that the deficiency of iron and zinc was traced to the oversupply of phosphorus and thereby caused the reduction in crop yields. It is desirable that the crop should have a high phosphatic content directly advantageous to animals and man. It is for this objective also that the soils found deficient in phosphorus should be liberally supplied for better nutrition of the plant, animal and man. The plant can absorb the phosphate in the highest oxidized form of orthophosphoric acid $[(NH_3)_2 PO_4]$ as PO_4 or as H_2PO_4 ion according to Jacob and Uexkull. But in the soil the phosphoric acid occurs in the highly insoluble form of apatites $[3Ca_3(PO_4)_2 . CaFe]$ or $[3Ca_3(PO_4)_2 . Ca(OH)_2]$, ferric phosphate and aluminum phosphate. It has been further observed that the water soluble phosphorus are easily converted into unavailable forms due to iron and aluminum. In the lateritic soils, those of high iron and aluminum contents, fixation of phosphorus takes place very rapidly so that plants can utilize the water soluble phosphates only in meager amounts. In the apatite forms the fixation of phosphorus proceeds very slowly due to the slow rate of crystallization of the mineral formed. There is also a certain fraction of soil phosphorus coming from organic matter which becomes available to plants when such organic matter is mineralized. Phosphate movement in the soil is rather slow and therefore leaching is considered negligible. More phosphate losses are likely due to soil erosion. Only very relatively small amounts are removed by plants.

The amounts of available phosphorus in the soil for plant growth vary according to soil type and climate. For Wisconsin soils in the United States, Truog[2] found that the minimum available phosphorus should be 37.5 p.p.m. for good

[2] Emil Truog, "The Determination of the Readily Available Phosphorus of Soils," *Journal of American Society of Agronomy*, 22: 874-882 (1930).

clay soil and 25 p.p.m. for sandy soils. Also for the southern United States where there is a longer growing period, 10 to 15 p.p.m. available phosphorus might be sufficient for a good crop of corn. In the Philippines, however, Marfori[3] basing on data obtained from various soil types stated that 30 to 40 p.p.m. of available phosphorus, determined by the Truog method seem to be the normal requirement for rice and other grain crops.

From table 12 it can be observed that the available phosphorus of the soils of Ilocos Norte Province are rather low, very critical and require almost the maximum recommendation of 300 kg. of single superphosphate (20% P_2O_5) per hectare. The figures obtained ranging from 1 p.p.m. to 9 p.p.m. are very far below that values set by Marfori. Bantay clay loam with 9 p.p.m. of available phosphorus approximates that of Truog for southern United States.

Potassium.—Potassium is one of the major elements essential to plant growth. While it is not combined with any of the organic compounds in the plant cells it occurs in solution in the cell sap or absorbed in the plasma. This element accumulates in the parts of the plant in which the cell division and growth processes actively proceed. It is usually transported from the older leaves to the young meristematic tissue in cases of deficiency. The main function of potassium is to maintain the swelling of the plasma colloids necessary for the metabolic processes. It also keeps the water economy of the plant in equilibrium to reduce any tendency of wilting. It maintains the balance between anabolism, respiration and transpiration. It is also believed and reported that it has something to do with the assimilation of carbon dioxide; formation, condensation, and transportation of sugars; synthesis of proteins and fats. Potash stimulates cell division, absorption and reduction of nitrates, and further regulates the activities of many enzymes.

Jacob and Uexkull and many others reported that there is an antagonism between this element and nitrogen and any excess of nitrogen produces an effect of potash deficiency and

[3] R. T. Marfori, "Phosphorus Studies on Philippine Soils. I. The Readily Available Phosphorus of Soils as Determined by the Truog Method," *Philippine Journal of Science*, 70: 133-142, (1939).

conversely. There is also an antagonism of this element towards calcium and magnesium. It has been practiced however, that to correct an over application of nitrogen, potash is the antidote or is applied to counteract the excessive effect of the nitrogen. Potash is responsible for the strengthening or hardening of the supporting tissues rendering the plants resistant to pests and diseases and for the superior keeping qualities of fruits. Excessive application of this element to the soil however, stimulates magnesium deficiency. This element is absorbed by plants in the monovalent form positively charged potassium ion regardless of its source. Of the amount of potash present in the soil, only a very small amount is available through cation exchange. In calcareous soils, a very low content of potassium may be found; light soils are usually poor in this element, while in heavy soils appreciable amount exists. In this case it is said that there is a very slight danger of loss by leaching.

Potash deficiency is characterized by the yellowing of the tips and margins of older leaves moving towards the bases of the leaves. This is also shown on the younger leaves. As the symptom advances, the yellowish portion becomes necrotic, appears reddish brown and brownish gray in color, and die off. Such symptom becomes very apparent during dry seasons or in cases of sudden occurrence of drought.

This element makes up about 40% of the ash content of most plants. Millar and Turk[4] states that potassium increases the plumpness of grains and makes the stalks and stems of plants more rigid thus minimizing lodging. The ears of the corn when grown on potash deficient soils appear chaffy, tips and cobs taper, and the kernels are loose on the cobs. In tobacco, potassium improves its texture, color and combustibility. In many plants it increases the sugar, starch, and oil contents and improves the taste and keeping quality of fruits. In citrus, excess potassium affects quality because it induces large coarse fruit with a thick skin which ripens unevenly.

The major portion of the soil potassium exists in unavailable form. The amount of water soluble form is so small and

[4] C. E. Millar and L. M. Turk, *Fundamentals of Soil Science*, (New York: John Wiley and Sons, Inc., 1943).

is easily lost through leaching and drainage. Where the base exchange capacity of the soil is large and the total exchangeable base contents is low, parts or all of the potassium added as fertilizer become fixed in the clay minerals and stored for future use by the plants.

Bray[5] reported that no response to fertilization in corn was observed in Illinois and in the corn belt when the soils had 150 p.p.m. or more of available potassium. In Oklahoma, Murphy[6] reported that there was a favorable response to potash fertilization in soils having less than 60 p.p.m. of replaceable potassium. Soils with 100 to 124 p.p.m. of available potassium have doubtful responses and those with 155 to 170 p.p.m. or more have no response at all. Locsin[7] reported a positive crop response to potash fertilization in Negros Occidental in his sugar cane experiment with 85 p.p.m. or less while soils containing 151 p.p.m. or more gave negative response. Where the soil is highly deficient in available potassium, potassic fertilizers will not give immediate significant increase in crop yield because of the fixation of the added potassium in the base exchange complex of the soil, as revealed by Marfori, et al[8] in their rice experiments. However, large initial application of potassium fertilizer on soils highly deficient in available potassium will saturate the potassium fixing capacity and therefore, leave enough readily available potassium for the immediate need of the plants. It was found further that on San Manuel silt loam containing 161 p.p.m. of available potassium repeated large applications of potassic fertilizer did not give any significant increase in yield with Guinangang rice variety as indicator.

[5] R. H. Bray, *Soil Test Interpretation and Fertilizer Use*, Department of Agronomy, University of Illinois, Bulletin 1220, (Springfield, Illinois: University of Illinois Press, 1944).

[6] H. F. Murphy, "The Replaceable Potassium Content Compared with Field Response to Potash Fertilization of Some Oklahoma Soils," *Journal of American Society of Agronomy, 26*:34–37, (1934).

[7] Carlos L. Locsin, "Potash Fertilization of Sugar Cane at Victorias, Negros Occidental," *Journal of the Soil Science Society of the Philippines, 2*:105–108, (1950).

[8] R. T. Marfori, et al, "A Critical Study of Fertilizer Requirements of Lowland Rice on Some Philippine Soil Types," *Journal of the Soil Science Society of the Philippines, 2*:155–172, (1950).

Therefore, from the results obtained and gathered from here and abroad it may be safe to assume that 100 to 150 p.p.m. of available potassium is the average minimum requirement of most crops like rice, corn and sugar cane. From the table of chemical analysis of the various soil types the potassium content ranges from 94 p.p.m. represented by San Manuel sand to 200 p.p.m. that of Cervantes clay loam. Only San Manuel sand and Umingan clay loam have available potassium below 100 p.p.m. and therefore, require potassic fertilization, especially for rice, corn and sugar cane crops. Majority of them, however, do not require potassic fertilizer, but in the case of tobacco, with the minimum available potassium content of 175 p.p.m. only four soil types namely, Umingan sandy loam with 188 p.p.m., Bantog silty clay with 175 p.p.m., Cervantes clay loam with 200 p.p.m., and Faraon clay with 177 p.p.m. do not require any potassic fertilizer. It was further observed that the best and superior quality Virginia tobacco produced in Ilocos Norte was grown in Batac. The soil type is San Manuel clay loam with available potassium content of 123 p.p.m.

Calcium.—Calcium is one of the essential plant nutrients affecting the soil, physically and biologically. Other authors regard it as a soil ameliorant because it brings acid soil to a more favorable soil reaction, like pH 6, in which most of our crops grow, besides improving the soil structure. It is also very important in the nutrition of plants. Calcium occurs in soils in a variety of minerals. For instance, carbonate of lime comprises a large percentage of the mineral matter where the soil is derived from limestone or chalk rocks. The element is readily leached in the soil. It also comprises the major portion of the elements held as exchangeable bases where the soils are not strongly acid and it is readily brought into solution. In plants it is a structural element and in combined form it is only present in the calcium pectin of the middle lamella of the cell wall. Together with other ions it controls the state of swelling of the plasma colloids, thereby influences the water economy of the plant, protein-carbohydrates in fat metabolism and many other physiological processes. This element may also influence the absorption of other elements either favorably or unfavorably. It has been found that ion antagonism exist between this element and potassium. While it

may counteract the toxic effects of high concentrations of potassium, magnesium, sodium and possibly boron, it causes the plasma to contract and thereby promotes transpiration while water absorption is reduced. Therefore, an excess of calcium restricts the uptake of potassium and this is true conversely.

As was mentioned earlier, the amount of calcium in the soil determines the physical structure of that soil. A soil high in calcium appears granular, is porous, and has good tilth. Calcium is responsible for the flocculation of soil colloids and affects the availability of soil phosphorus as this element is most readily available in a neutral to slightly acid reaction. Calcium availability decreases due to its combination with aluminum and iron forming insoluble aluminum and iron phosphate compounds. In the presence of excessive amounts of calcium carbonate of about 2% as in alkaline soils, it is precipitated as calcium phosphate which has very low solubility. This latter form, however, is more soluble than the phosphate of aluminum and iron.

When agricultural lime is applied to the soil it raises the pH and makes the soil phosphorus available to plants including the organic forms. The more desirable forms are the mono- and di-calcium phosphates. While this is so, in most depleted or phosphorus deficient soils, lime alone will not solve the problem of phosphorus deficiency. A liberal application of phosphatic fertilizer should follow to insure the availability of phosphorus.

Calcium is very important in microbial processes in three ways, namely: (1) it promotes the decomposition of organic matter, (2) it makes the condition favorable for nitrification and sulfofication, and (3) it provides favorable conditions for the growth and functioning of both symbiotic and non-symbiotic fixing bacteria. While lime is used to provide the nutrient element calcium, in the case of Irish potato, great care must be observed in liming the soil because at above pH 5.5 it may cause the favorable growth of the micro-organism causing the potato scab disease. The calcium element is slightly mobile in the plant and accumulates particularly in the older tissues. The deficiency of this element, however, can be noticed early as it appears first in the youngest tissues in the leaves around the growing point and at the root tips. Chlorosis also develops on the margins of the leaves. The leaf margins become contorted with brown scorching or spotting effect.

The calcium contents of cabbage leaves according to Smith and Hester,[9] have been increased from 4.42% to 7.53%. Likewise, the yield of tomatoes was doubly increased together with its vitamin C or ascorbic acid content and that it was also reported that the protein content of the corn grain was also increased by 40%. Also with the use of agricultural lime in their upland rice experiment Madamba and Hernandez[10] found and reported that the increased yield was due to the lime applied.

The calcium contents of the 33 soil types of Ilocos Norte Province range from 200 p.p.m., represented by Umingan sandy loam, to 16,900 p.p.m., that of Bantog silty clay loam, with an average of 5,025 p.p.m., as shown in table 12. There are only five soil types having calcium contents below 2,000 p.p.m. which are considered deficient in this element. They are Umingan sandy loam, Bantog sandy loam, Cervantes clay loam, Tadao sandy clay loam, and Luisiana clay loam. All others have sufficient quantities and fall within the range of 2,000 to 6,000 p.p.m. which is the average range of available calcium in Philippine soils.

Magnesium.—Magnesium is an essential plant nutrient because it is a constituent of the chlorophyll, protochlorophyll, pectin, and phytin. Only a small portion of the total magnesium combines with this group; the greater part is dissolved in the cell sap and is very mobile in the plant. This element is known to be a carrier of phosphorus and therefore becomes essential in the function of seeds of high oil content. It also participates in the production of carbohydrates, proteins and fats, catalytic reactions in the enzymes besides formation of

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[9] G. F. Smith and J. B. Hester, "Calcium Content of Soils and Fertilizer in Relation to Composition and Nutritive Value of Plants", *Soil Science, 75,* pp. 117–128, (1948).

[10] A. L. Madamba and C. C. Hernandez, "The Effect of Ammophos and Lime on the Yield of Upland Rice Grown on Buenavista Silt Loam", *Journal of the Soil Science Society of the Philippines, 1*:204–208, (1948).

vitamins. Under certain conditions it promotes the absorption and translocation of phosphoric acid. Magnesium is absorbed in the form of a divalent cation and can be supplied as sulphate, phosphate, carbonate or oxide. It can be fixed in many soils in a non-exchangeable form ($MgCO_3$). Absorption of this element is promoted by nitrate ions but restricted by the ammonium ions, potassium ions and calcium ions.

Deficiency of this element usually occurs in older leaves first and later in the younger leaves. This is revealed by the disappearance of the chlorophyll in the form of spots between the veins of the leaves. The yellow discolorations generally commence at the leaf margins and first comprise the interveinal areas, the veins remaining green. The chlorosis of tobacco known as "Sand Drown" is due to magnesium deficiency. In cotton, it produces purplish red leaves with green veins, but in corn and soybean, the leaves become striped, with veins remaining green; areas between veins become purplish in soybeans but yellow in corn. In citrus, it causes a reduction in crop yield, size of fruit and sugar and vitamin C content of the juice. The plants belonging to Gramineae family seem insensitive to magnesium deficiency. It was reported that in southern United States and in Massachussetts its deficiency in corn is intensified by the unbalanced plant nutrient condition as a result of the continuous use of sodium salts as fertilizer for other crops in rotation with corn. Magnesium deficiency is likely to prevail in sandy soils during seasons of heavy rainfall. To correct magnesium deficiency in the soil, addition of dolomitic limestone and/or magnesium sulfate is a common practice.

The magnesium content of the various soil types in the provinces ranges from a minimum of 140 p.p.m., represented by Luisiana clay loam, to a maximum of 4,750 p.p.m., represented by San Fernando sandy loam. For Philippine soils, the various soil types which rated high in crop productivity gave an average range of 600 p.p.m. to 1,700 p.p.m. of available magnesium content. In Ilocos Norte, there are only four soil types, namely, San Manuel sand, Umingan sandy loam, Tadao sandy clay loam, and Luisiana clay loam with available magnesium below the 600 p.p.m. level.

Manganese.—Manganese is one of the trace elements needed by plants which functions like a catalyst. Its activities are especially concerned with the oxidation–reduction reactions within the plant tissue. Like iron, it is also necessary for the formation of chlorophyll, reduction of nitrates, respiration and other metabolic processes. This element is absorbed by plants in the divalent form. The acid reaction of the soil, poor aeration and high humus content promote reduction of manganese to the divalent form which makes it readily available and assimilable. In alkaline reaction with all measures favoring oxidation processes in the soil by the micro-organisms, fixation of manganese may be favored. Absorption of this element is promoted by potassium. Excessive amounts of manganese in the soil may cause iron deficiency, yet the plants may simultaneously suffer from both elements, as shown particularly by the chlorotic appearance of the young shoot which is due to iron deficiency and due to the mobile activity of manganese. The chlorotic symptoms simultaneously appear on the older leaves, sometimes resembling the symptom resulting from magnesium deficiency in which the interveinal areas become bleached with the veins remaining green. Solubility of the soil manganese increases with increased acidity and frequently becomes toxic in its concentrations. Among many soils at above pH 6.5, this element becomes unavailable due to the oxidizing bacteria. Availability of this nutrient element depends largely on the organic matter present and drainage condition. Deficiency of this element usually occurs in calcareous peats, and in other soils with high organic matter and those heavy limed soils with high water tables. According to literature, the manganese contents of crops like cabbage, radish, rice grain and tomato fruits are 34 p.p.m., 29 p.p.m., 23 p.p.m., and 46 p.p.m., respectively. The dwarfing of the plants like tomatoes, beans, oats, tobacco and many others are traced back from the very low manganese content. Curling of the onion leaves with immature bulbs at harvest time indicates also shortage of this element. In celery, the leaves become yellow while in spinach, lettuce and potatoes, stunting, chlorosis and curling of margins are manifested. If toxicity occurs as in sugar beat, the leaves show strong chlorotic mottling. The manganese contents of the various soil types in the province

range from a minimum of 10 p.p.m., represented by San Manuel sand and Luisiana clay loam, to a maximum of 142 p.p.m., that of San Manuel silt loam. The various soil types in the Philippines with high crop productivity analyzed for available manganese contained from about 15 p.p.m. to 250 p.p.m. From these observations there are only two soil types in the province that appear deficient in this element while all others are sufficient.

Iron.—Iron is not a constituent of chlorophyll. Its role is that of a catalyst. The iron deficiency usually means iron immobility, as mobility of this element is affected by the presence of manganese, potassium deficiency and high light intensity. This element is a constituent of various enzymes. It can be absorbed in the divalent form. In strongly calcareous soils a secondary deficiency of iron is brought about as a result of the precipitation of available iron compounds. The fixation of iron in the soil, excessive calcium, manganese or copper in the plant cause a physiological iron deficiency. Symptoms of iron deficiency appear on the youngest shoots. The leaves remain small with a pale yellow color turning almost white. Spraying ferrous iron sulphate singly or in combination with commercial fertilizers to the foliage especially with chelates, besides its direct application to the soil, may correct deficiency of iron. It was observed and reported also that Gramineae are insensitive to iron deficiency. While it is present in most soils it is in the form of oxides as reflected by red or brown colors. With good drainage and aeration the ferric iron compounds predominate while in water-logged soils the ferrous iron compounds prevail. The availability of this element to plants increases with increased acidity. The iron contents of the various soil types of the province range from a minimum of 1 p.p.m. represented by Bantog sandy loam, Bantog loam, and Faraon clay loam, to a maximum of 136 p.p.m., that of Umingan silty clay loam. Soil samples of various soil types obtained from various places with high crop productivity were analyzed for available iron and they revealed a range of from 2 p.p.m. to a maximum of 30 p.p.m. It, therefore, shows that the three soil types which contain only 1 p.p.m. appear slightly deficient. All others fall within the range. In passing, other vital nutrient elements classified as minor or trace elements not discussed here are boron, copper, zinc, and molybdenum. Sulfur is classified as a major element and occurs in plants as a constituents of proteins, connected with chlorophyll formation.

FERTILIZER AND LIME REQUIREMENTS

Excepting nitrogen all the major elements and minor or trace elements essential to plant growth come or are found in the soil. They are all essential because the plants take or need some of them in large quantities or in small amounts. The trace elements when present in large quantities in the soil act as poison or become toxic to plants. There are other elements known to affect growth and crop responses such as nickel, chromium, gallium, sodium, chlorine, and silica, but they have not been so far established as absolutely essential to plant growth. Aluminum, because of its general occurence in plants, has direct influence in plant nutrition.

Nutrient elements available in the soil are not inexhaustible. Neither are they properly and readily apportioned and to be more specific, balanced for proper plant growth. But all said and done to mother nature's varied activities, processes and reactions besides those of man for livelihood, comfort and conveniences, depletion of these elements from the soil has caused the alarming tendencies of low crop yields. As always said, the greatest source of wealth is the soil. It becomes illimitable and could run for generations only if and when proper scientific methods of soil and water management are applied. Conservation measures which should include a well planned fertilizer program for the entire province need immediate implementation. It is necessary for all the soil types of Ilocos Norte on which all the major crops like rice, corn, tobacco, onion, garlic, sugar cane and mongo are grown that commercial fertilizers, and perhaps in some cases lime, be applied to increase crop yields. The availability of the various nutrients in the soil and their uptake by plants are affected by various factors such as temperature, light intensity, drought, plant pests and diseases, poor aeration and drainage, soil texture, ion antagonism, soil reaction and perhaps the agricultural practices of the farmers.

The lime and fertilizer recommendations for lowland rice, upland rice, Virginia tobacco, native tobacco, garlic, onion, mongo and sugar cane indicated in table 13 are based on the results obtained from the chemical analysis of the different soil types of the province.

TABLE 13.—*Lime and fertilizer recommendations for certain soil types of Ilocos Norte.*

Soil type	Agricultural lime[1] ($CaCO_3$) Ton/ha.	Ammonium sulfate (20% N) Kg./ha	Superphosphate (20% P_2O_5) Kg./ha.	Muriate of potash (60% K_2O) Kg./ha.
	For lowland rice			
Bantog clay	----	230	350	50
Bantog clay loam	----	100	300	50
Bantog silty clay	2.75	260	350	50
Bantog silty clay loam	----	200	350	50
Bolinao clay loam	----	280	300	50
Bolinao loam	----	180	300	50
Maligaya silty clay loam	----	180	350	50
San Fernando clay	----	230	300	50
San Fernando clay loam	----	230	300	50
San Fernando sandy loam	----	150	350	50
San Fernando silty clay	----	150	350	50
San Manuel clay loam	----	230	350	50
San Manuel loam	----	230	300	50
San Manuel sand	----	280	350	100
San Manuel sandy clay loam	----	280	350	50
San Manuel sandy loam	----	180	350	50
San Manuel silt loam	1.00	180	300	50
San Manuel silty clay	----	230	300	50
San Manuel silty clay loam	----	260	350	50
Umingan clay loam	0.50	180	350	100
Umingan loam	----	230	300	100
Umingan sandy loam	4.25	180	350	----
Umingan silty clay loam	0.50	50	350	50
Tadao sandy clay loam	2.75	280	350	50
	For upland rice			
Annam clay loam	----	180	300	----
Bantay clay loam	----	100	250	50
Bantay loam	----	280	350	50
Bantog sandy loam	5.50	260	350	50
Bantog silt loam	----	260	300	50
Bantog silty clay loam	----	200	350	50
Bolinao clay loam	----	280	300	50
Bolinao loam	----	100	300	50
Maligaya silty clay loam	----	180	350	50
San Fernando clay loam	----	230	300	50
San Fernando sandy loam	----	150	350	50
San Manuel sandy clay loam	----	280	350	50
San Manuel sandy loam	----	100	300	50
Tadao sandy clay loam	5.50	280	350	50
Umingan sandy loam	8.50	180	350	----
	For corn			
Bantog clay loam	----	150	300	50
Bantog sandy loam	5.5	300	350	100
San Fernando clay	----	300	350	50
San Fernando clay loam	----	150	300	100
San Fernando sandy loam	----	150	350	100
San Manuel clay loam	----	300	350	100
San Manuel loam	----	300	350	50
San Manuel sand	----	300	350	150
San Manuel sandy clay loam	----	300	350	100

[1] Limestone pulverized to 20 mesh and about 50% to pass through 100 mesh.

TABLE 13.—*Lime and fertilizer recommendation for certain types of Ilocos Norte.*—(Continued)

Soil type	Agricultural lime ($CaCO_3$)	Ammonium sulfate (20% N)	Super-phosphate (20% P_2O_5)	Muriate of potash[2] (60% K_2O)
	Ton/ha.	Kg./ha	Kg./ha.	Kg./ha.
San Manuel silt loam	----------	300	300	100
San Manuel silty clay	----------	300	300	100
San Manuel silty clay loam	----------	300	350	50
Umingan clay loam	----------	300	350	150
Umingan loam	----------	300	300	150
Umingan sandy loam	8.5	300	350	----------
	For Virginia tobacco			
Bantog clay	----------	250	300	120
Bantog clay loam	----------	50	300	60
Bantog silt loam	----------	160	300	60
Bantog silty clay	----------	120	300	----------
Bantog silty clay loam	----------	130	350	60
Maligaya silty clay loam	----------	120	350	60
San Fernando clay	----------	150	350	60
San Fernando clay loam	----------	150	300	120
San Manuel loam	----------	150	300	60
San Manuel silt loam	----------	120	300	120
San Manuel silty clay	----------	150	300	120
San Manuel silty clay loam	----------	160	350	60
	For native tobacco			
San Manuel clay loam	----------	200	350	120
San Manuel loam	----------	200	300	60
San Manuel silt loam	----------	200	300	120
San Manuel silty clay	----------	200	300	120
	For garlic			
Bantog clay	----------	300	300	100
Bantog silt loam	----------	300	300	100
San Fernando clay	----------	300	350	50
San Fernando clay loam	----------	300	300	100
San Manuel clay loam	----------	300	350	100
San Manuel loam	----------	300	300	50
San Manuel sandy loam	----------	150	300	100
San Manuel silt loam	----------	300	300	100
San Manuel silty clay	----------	300	300	100
San Manuel silty clay loam	----------	300	350	50
	For onion			
Bantog clay	----------	300	300	100
Bantog silt loam	----------	300	300	50
San Fernando clay loam	----------	300	300	100
San Manuel clay loam	----------	300	350	100
San Manuel silt loam	----------	300	300	100
San Manuel silty clay loam	----------	300	350	50
	For mongo			
San Fernando clay loam	----------	100	300	50
San Fernando sandy loam	----------	100	350	50
San Manuel loam	----------	100	300	50
San Manuel sandy loam	----------	----------	300	50
San Manuel silt loam	----------	100	300	50
San Manuel silty clay	----------	100	300	50
San Manuel silty clay loam	----------	100	350	50
Umingan clay loam	----------	100	350	100
Umingan loam	----------	100	300	100

[2] For tobacco, sulfate of potash (50%) (K_2O) instead of muriate of potash is recommended.

TABLE 13.—*Lime and fertilizer recommendations for certain soil types of Ilocos Norte.*—(Continued)

Soil type	Agricultural lime ($CaCO_3$)	Ammonium sulfate (20% N)	Super-phosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	Ton/ha.	Kg./ha	Kg./ha.	Kg./ha.
	For sugar cane			
Bantog sandy loam	5.5	500	690	100
Bantog silt loam	----------	500	575	50
San Fernando clay	----------	500	690	50
San Fernando silty clay	----------	500	690	100
San Manuel sandy clay loam	----------	500	690	100
San Manuel sandy loam	----------	250	575	100
San Manuel silty clay loam	----------	500	690	50
Umingan clay loam	----------	500	690	200

The agricultural lime generally recommended for use is calcium carbonate or limestone with an analysis of 85% to 98% CaO, pulverized to pass through 20 mesh sieve, 50% of which to pass through 100 mesh. Burnt lime or calcium oxide may be used also but the soil reaction is quite violent which is unlike that of limestone where the soil reaction is not violent and the release of Ca-ions is gradual.

The most common commercial fertilizers available in the market as sources of nitrogen (N), phosphorous (P_2O_5), and potassium (K_2O) are ammonium sulphate (20% N), single superphosphate (20% P_2O_5), and muriate of potash (60% K_2O). These may be used for all crops except tobacco. While tobacco is a potash loving plant, muriate of potash is not generally recommended because it adversely affects the burning quality of tobacco. Instead, sulfate of potash is recommended.

The lime and fertilizer recommendations given in this soil report are not absolute, but they are, however, the nearest approximations to obtain optimum crop responses. In the absence of commercial fertilizers and lime the local materials available and known to be good sources of some of these elements [11] are guano, animal and green manures, rice hull ash, and kitchen or wood ash. They could be utilized to advantage even if their chemical compositions may be rather low.

[11] I. E. Villanueva, "The Potassium Deficiency of Philippine Soils." *Science Quarterly*, 2: 24–27, (1960).

The commercial fertilizers are also classified into nitrogenous, phosphatic, and potassic fertilizers. The nitrogenous fertilizers usually carry either the ammonia (NH_3) form or the nitrate (NO_3) form. For instance, liquid ammonia, ammonium sulfate, ammonium phospate and urea carry the former while potassium nitrate and sodium nitrate carry the nitrate form. Fish and guano are good sources of nitrogen and are called organic fertilizers because their nitrogen are in organic forms.

The phosphatic fertilizers are both water soluble and water insoluble compounds. Rock phosphate, basic slag and guano are water insoluble. They are preferably used in acid soils as they become soluble in an acid medium. Basic slag is intensely alkaline because it contains large amounts of calcium hydroxide. The ordinary, double and treble superphosphates have their phosphates mostly in the monocalcium forms which are very soluble in water. Ammonium phosphate (Ammophos) also has its phospate soluble in water. The ordinary superphosphate contains calcium, gypsum, and sulfur in adequate amounts suitable in plant nutrition, while the double and treble superphosphates contain a negligible amount of calcium and sulfur.

The most common potassic fertilizers are muriate of potash (60% K_2O) and sulfate of potash (50% K_2O). They are highly soluble in water and are acid forming, hence, great care and precaution should be exercised in their use and storage.

For best results and positive effects in the use of fertilizers the manner and time of their application must be considered. For instance, if broadcast, the leaves of the plants should be dry. For band fertilizer placement, uniform distribution is desirable; fertilizer should be placed within the root zone of the plants so that their absorbing root hairs have proximity to the nutrient elements.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN ILOCOS NORTE

Common Name	Scientific Name	Family
Abaca	*Musa textilis* Nee	Musaceae
Achuete	*Bixa orellana* Linn.	Bixaceae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Akle	*Albizzia acle* (Blanco) Merr.	Leguminosae
Alibangbang	*Bauhinia malabarica* Roxb.	Leguminosae
Alugbate	*Basella rubra* Linn.	Basellaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Anibong	*Oncosperma tigilaria* (Jack.) Ridl.	Palmae
Anonang	*Cordia dichotoma* Forst.	Boraginaceae
Api-api	*Avicennia officinalis* Linn.	Verbenaceae
Apitong	*Dipterocarpus grandiflorus* Blanco	Dipterocarpaceae
Arrowroot	*Maranta arundinacea* Linn.	Marantaceae
Avocado	*Persea americana* Mill.	Lauraceae
Badiang	*Alocasia macrorrhiza* Linn. Schott.	Araceae
Bakauan	*Rhizophora mucronata* Linn.	Rhizophoraceae
Bakauan-lalaki	*Rhizophora candelaria* D. G.	Rhizophoraceae
Balete	*Ficus altissima* Blume Bijdr.	Moraceae
Balimbing	*Averrhoa carambola* Linn.	Oxalidaceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceae
Banana	*Musa sapientum* Linn.	Musaceae
Bangkal	*Nauclea orientalis* Linn.	Rubiaceae
Batad	*Andropogon sorghum* (Linn.) Brot.	Gramineae
Batao	*Dolichos lablab* Linn.	Leguminosae
Bermuda grass	*Cynodon dactylon* (Linn.) Pers.	Gramineae
Betel nut	*Areca catechu* Linn.	Palmae
Binayuyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineae
Breadfruit	*Artocarpus communis* Forst.	Musaceae
Buri	*Corypha elata* Roxb.	Palmae
Cabbage	*Brassica oleracea* Linn. var. *capitata* Linn.	Cruciferae
Cacao	*Theobroma cacao* Linn.	Sterculiaceæ
Cadios	*Cajanus cajan* (Linn.) Milsp.	Leguminosae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Cassava	*Manihot esculenta* Crantz	Euphorbiaceae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Chico	*Achras sapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea arabica* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae

Common Name	Scientific Name	Family
Corn	*Zea mays* Linn.	Gramineae
Cotton	*Gossypium hirsutum* Linn.	Malvaceae
Cowpea	*Vigna sinensis* (Linn.) Savi	Leguminosæ
Coronitas	*Lantana camara* Linn.	Verbenaceae
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceae
Custard apple	*Anona reticulata* Linn.	Anonaceae
Dayap	*Citrus aurantifolia* (Christem) Swingle	Rutaceae
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
Guijo	*Shorea guiso* (Blanco) Blume.	Dipterocarpaceae
Guisok	*Shorea balangeran* (Korth) Dyer	Dipterocarpaceae
Indigo	*Indigofera suffruticosa* Mill.	Leguminosae
Ipil	*Instia bijuga* (Colebr.) Kuntze.	Leguminosae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae
Jackfuit	*Artocarpus heterophyllus* Lam.	Moraceae
Kalamansi	*Citrus microcarpa* Bunge	Rutaceae
Kalabasa	*Cucurbita maxima* Duchesne	Cucurbitaceae
Kamachile	*Pithecolobium dulce* (Roxb.) Benth.	Leguminosae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Kangkong	*Ipomea aquatica* Forsk.	Convolvulaceae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Katuray	*Sesbania grandiflora* (Linn.) Pers.	Leguminosae
Kondol	*Benincasa hispida* (Thumb.) Gogn.	Cucurbitaceae
Langaray	*Bruguiera parviflora* (Roxb.) W & A	Rhizophoraceae
Lauan (white)	*Pentame contorta* (Vidal) Merr. & Rolfe.	Dipterocarpaceae
Lemon	*Citrus limonia* Osbeck Reise Ostind	Rutaceae
Lemon grass	*Andropogon citratus* DC Cat. Hort. Monsp.	Gramineae
Lettuce	*Lactuca sativa* Linn.	Compositae
Mabolo	*Diospyrus discolor* Willd.	Ebernaceae
Madre cacao	*Gliricidia sepium* (Jacq.) Steud.	Leguminosae
Macopa	*Eugenia mallaccensis* Linn.	Myrtaceae
Maguey	*Agave cantala* Roxb.	Amaryllidaceae
Malungay	*Moringa oleifera* Linn.	Moringaceae
Mandarin	*Citrus nobilis* Lour.	Rutaceae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Mongo	*Phaseolus aureus* Roxb.	Leguminosae
Melon	*Cucumis melo* Linn.	Cucurbitaceae
Narra	*Pterocarpus indicus* Willd.	Leguminosae

Common Name	Scientific Name	Family
Nipa	*Nypa fruticans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Orange	*Citrus aurantium* Linn.	Rutaceae
Pandan	*Pandanus tectorius* Sol.	Pandaneceae
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
Pepper	*Capsicum annuum* Linn.	Solanaceae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromiliaceae
Pummelo	*Citrus maxima* (Burm.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferae
Rattan	*Calamus spp.*	Palmae
Rain tree	*Samanea saman* Merr.	Leguminosae
Rice	*Oryza sativa* Linn.	Gramineae
Santol	*Sandoricum koetjape* (Burm. F.) Merr.	Myrtaceae
Seguidilla	*Psophocarpus tetragonolobus* (Linn.) DC.	Leguminosae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Sineguelas	*Spondias purpurea* Linn.	Anacardiaceae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Soybean	*Glycine max* (Linn.) Merr.	Leguminosae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Sweet potato	*Ipomoea batatas* Linn.	Convulvolaceae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Tamarind	*Tamarindus indicus* Linn.	Leguminosae
Teak	*Tectona grandis* Linn.	Verbenaceae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solonaceae
Tugui	*Dioscorea esculenta* (Lour.) Burkill.	Dioscoreaceae
Tangile	*Shorea polysperma* (Blanco) Merr.	Dipterocarpaceae
Tindalo	*Pahudia rhomboidea* (Blanco) Prain.	Leguminosae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Watermelon	*Citrullus vulgaris* Schrad.	Cucurbitaceae
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceae

BIBLIOGRAPHY

Anonymous, *Diagnostic Techniques for Soils and Crops.* Edited by Firman E. Bear and Hermania B. Kitchen. American Potash Institute, N.W., Washington, D.C. p. 308, 1948.

Arciaga, Antonio M. and N. L. Galvez. "The Effect of Soil Reaction (pH) on the Growth of Pet-sai Plants and on their Nitrogen, Calcium and Phosphorus Content." *Philippine Agriculturist 32:* 55–59, 1948.

Association of Official Agricultural Chemist. *Official Tentative Methods of Analysis.* Sixth edition. Washington, D.C.: Association of Official Agricultural Chemists, 1945.

Baldwin, Mark, Charles E. Kellogg and James Thorne. "Soil Classification," *Soils and Men.* The Yearbook of Agriculture: 1938. Washington: Government Printing Office, (n.d.).

Beyers, H. G. et al. "Formation of Soils," *Soils and Men.* The Yearbook of Agriculture: 1938. Washington: Government Printing Office, (n.d.).

Bray, R. H. *Soil Test Interpretation and Fertilizer Use.* Department of Agronomy, University of Illinois, Bulletin 1220. Springfield, Illinois Press, 1944.

Brown, William H. *Useful Plants of the Philippines.* Department of Agriculture and Commerce, Technical Bulletin 10. 3 Vols. Manila: Bureau of Printing, 1941 & 1946.

Bureau of the Census and Statistics. *Census of the Philippines: 1960. Agriculture.* Vol. I, Report by Province, Ilocos Norte, 21. Manila: Bureau of the Census and Statistics, 1963.

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

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

Camp, A. F., and others. *Hunger Signs in Crops.* Washington American Society of Agronomy and the National Fertilizer Association, 1941.

Dagdag, B. C., and others. *Soil Survey of Cagayan Province.* Department of Agriculture and Natural Resources, Soil Report No. 36. Manila: Bureau of Printing, 1965.

Department of Agriculture and Natural Resources. *Handbook of Agriculture: 1959.* Manila: Bureau of Printing.

Jacob, A. and H. Uexkull. *Fertilizer Use.* Hannover: Verlagsgesellschaft fur Ackerbau MbH, 1958.

Locsin, Carlos L. "Potash Fertilization of Sugar Cane at Victorias, Negros Occidental, "*Journal of the Soil Science Society of the Philippines, 2:* 105–108, 1950.

LYON, T. L. AND H. O. BUCKMAN. *The Nature and Properties of Soils.* Revised by Harry O. Buckman, Fourth edition. New York: The Macmillan Company, 1943.

MADAMBA, A. L. AND C. C. HERNANDEZ. "The Effect of Ammophos and Lime on the Yield of Upland Rice Grown on Buenavista Silt Loam," *Journal of the Soil Science Society of the Philippines 1:* 204–208, 1948.

MARFORI, R. T. "Phosphorus Studies on Philippine Soils. 1. The Readily Available Phosphorus of Soils as Determined by the Truog Method," *Philippine Journal of Science, 70:* 133–142, 1939.

MARFORI, R. T., I. E. VILLANUEVA AND R. SAMANIEGO. "A Critical Study of Fertilizer Requirements of Lowland Rice on Some Philippine Soil Types," *Journal of the Soil Science Society of the Philippines, 2:* 155–172, 1950.

MARIANO, J. A., and others. *Soil Survey of Ilocos Sur Province.* Department of Agriculture and Natural Resources, Soil Report No. 19. Manila: Bureau of Printing, 1954.

MERRILL, ELMER D. *An Enumeration of Philippine Flowering Plants.* Bureau of Science, Publication No. 18. 4 vols. Manila: Bureau of Printing, 1922–1926.

MILLAR, C. E. AND L. M. TURK. *Fundamental of Soil Science.* New York: John Wiley and Sons, Inc., 1943.

MURPHY, H. F. "The Replaceable Potassium Content Compared with Field Response to Potash Fertilization of Some Oklahoma Soils," *Journal of American Society of Agronomy, 26:* 34–37, 1934.

PARKER, E. R. AND W. W. JONES. "Orange Fruit Sizes," *California Agriculture, 4:* No. 3, 5, & 10, 1950.

PEECH, MICHAEL AND LEAH ENGLISH. "Rapid Micro-chemical Soil Test," *Soil Science, 57:* 167–195, 1944.

ROLA, NENA A. AND N. L. GALVEZ. "Effects of Soil Reaction on the Growth of Upland Rice and on its Nitrogen, Calcium, Phosphorus and Iron Content," *Philippine Agriculturist, 33:* 120–125, 1949.

SMITH G. F. AND J. B. HESTER. "Calcium Content of Soils and Fertilizer in Relation to Composition and Nutritive Value of Plants," *Soil Science, 75:* 117–128, 1948.

SMITH, W. D. *Geology and Mineral Resources of the Philippine Islands.* Bureau of Science Publication No. 19. Manila: Bureau of Printing, 1924.

SPURWAY, C. H. "A Practical System of Soil Diagnosis," *Michigan Agricultural Experiment Station. Technical Bulletin 132,* 1939.

THATCHER, R. N. *The Chemistry of Plant Life.* New York: McGraw Hill Book Company, Inc., 1921.

TRUOG, EMIL. "The Determination of the Readily Available Phosphorus of Soils," *Journal of American Society of Agronomy, 22:* 874–882, 1930.

TRUOG, EMIL. "Lime in Relation to Availability of Plant Nutrients," *Soil Science, 65:* 1–7, 1948.

UNITED STATES DEPARTMENT OF AGRICULTURE. *Climate and Men.* The Yearbook of Agriculture: 1941. Washington: Government Printing Office, (n.d.).

UNITED STATES DEPARTMENT OF AGRICULTURE. *Soils and Men.* The Yearbook of Agriculture: 1938. Washington: Government Printing Office, (n.d.).

UNITED STATES DEPARTMENT OF AGRICULTURE. *Soil Survey Manual.* United States Department of Agriculture Handbook No. 18: Washington: Government Printing Office, 1951.

VILLANUEVA, I. E. "Soil Requirements and Fertilization of Virginia Tobacco", *Philippine Journal of Soil Conservation, 2:* 15–41, 1957.

VILLANUEVA, I. E. "The Potassium Deficiency of Philippine Soils," *Science Quarterly, 2:* 24–27, 1960.

WALKLEY, A. AND I. A. BLACK. "Determination of Organic Matter in Soils" *Soil Science, 37:* 29–38, 1934.

WALLACE, T. *The Diagnosis of Mineral Deficiencies in Plants.* London: His Majesty's Stationary Office, 1951.

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

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

WEIR, WILBERT WALTER. *Soil Science, Its Principles and Practice.* Chicago: J. B. Lippincott Co., 1936.

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