Mis. Or.

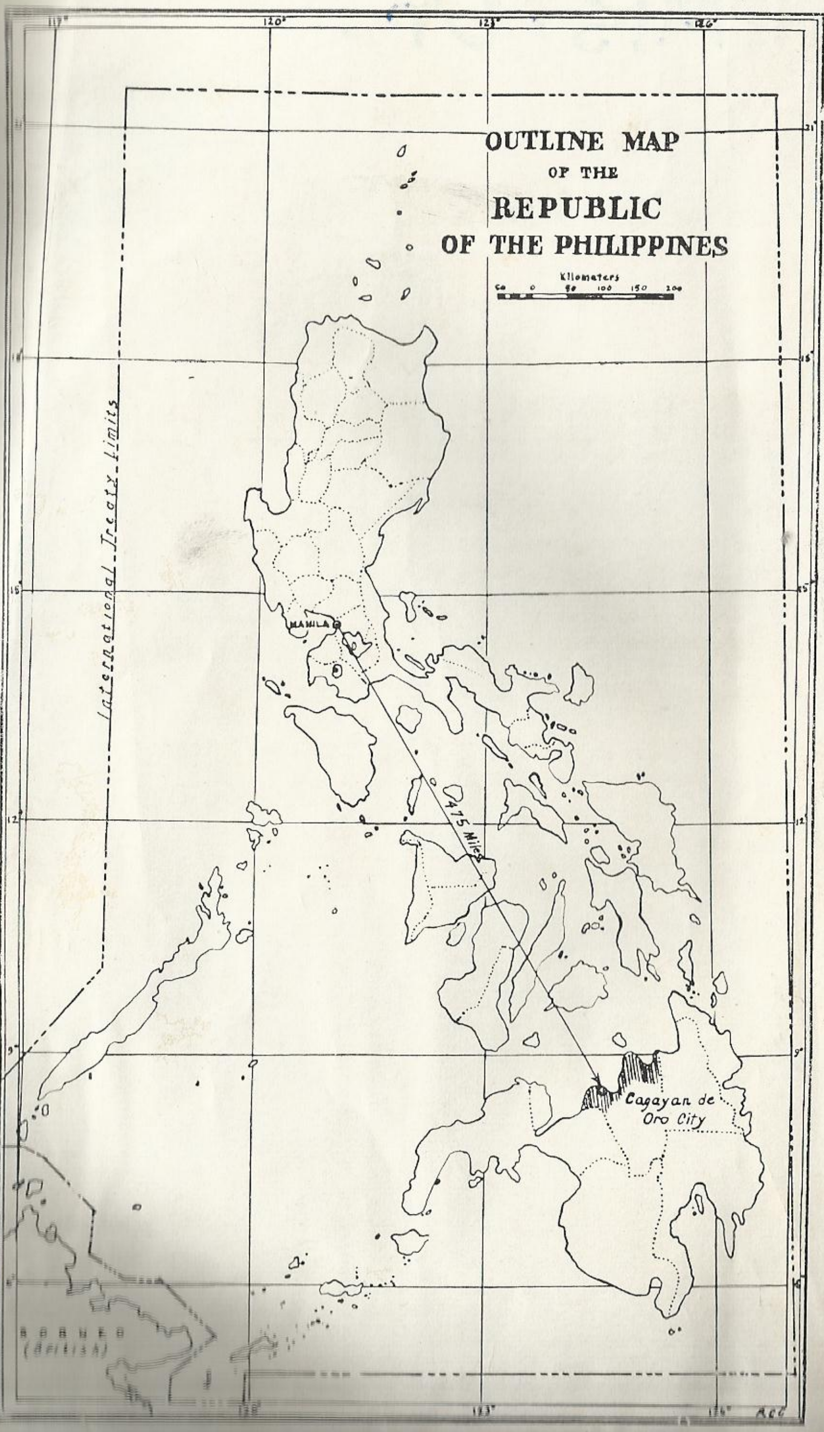

Fig. 1. Outline map of the Philippines showing the location and distance of Misamis Oriental.

REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
MANILA

Soil Report 20

SOIL CLASSIFICATION AND EROSION SURVEY OF MISAMIS ORIENTAL PROVINCE, PHILIPPINES

BY

FRANCISCO B. LOPEZ
Chief of Party

TEODOMERO M. YÑIGUEZ AND EDMUNDO K. VILLEGAS
Members

WITH A DISCUSSION ON THE CHEMICAL CHARACTERISTICS AND FERTILIZER REQUIREMENTS OF THE SOILS OF MISAMIS ORIENTAL PROVINCE

BY

RICARDO T. MARFORI, IGNACIO E. VILLANUEVA
AND GLORIA C. BANDONG

Published with FOA-PHILCUSA Aid

MANILA
ADBUREAU
1954

PREFACE

The Soil Classification and Erosion Survey of Misamis Oriental Province have been undertaken. The report with the accompanying maps is considered a handbook of the agriculture and soils of the province. It is a ready reference for a more effective agricultural development of the area, for soil researches, for students in agriculture, for agricultural settlement and colonization, and for correct land-use planning and soil conservation. While it may lack details, being only a reconnaissance, a good deal of information exists that when supplemented by a more systematic fact-gathering is decisive in solving the agricultural problems of the province.

It is hoped that the information herein would give valuable benefit to the farmers in general and the province in particular, and that if through this handbook the general agriculture of the province is improved the aims and purposes for which the work was undertaken would not be in vain.

The authors gratefully acknowledge the invaluable assistance rendered by the Honorable Provincial Board of Misamis Oriental, without which the work would not have been made possible. To Governor Paciencio G. Ysalina who generously assisted the Soil Survey Party in conducting the surveys of the province, to the Provincial Treasurer and Auditor who facilitated the prosecution of the work, and finally, to the Provincial Agricultural Supervisor and his personnel who made every effort for the success and early completion of the work and supplied the agricultural data, and to the Provincial Forester who unselfishly cooperated and supplied the needed forest data for the province, the authors are deeply indebted.

THE AUTHORS

HOW TO USE THE SOIL SURVEY REPORT

Soil Surveys provide basic data for the formulation of land-use programs. This report and the accompanying map present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part thereof. Ordinarily he will be able to obtain the information he needs without reading the whole report. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers under three general groups: (1) Those interested in the area as a whole; (2) those interested in specific parts of it; and (3) students and teachers of soil science and related agricultural subjects. An attempt has been made to meet the needs of all three groups by making the report comprehensive for purposes of reference.

Readers interested in the area as a whole include those concerned with general land-use planning—the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, and areas for forest and wildlife management and for recreation. The following sections are intended for such users (1) Description of the Area, in which physiography, relief, drainage, vegetation, climate, water supply, history, population, industries, transportation, markets, and cultural developments are discussed; (2) Agriculture, in which a brief history of farming is given with a description of the present agriculture; (3) Productivity Ratings, in which are discussed and presented the productivity of the different soils; (4) Land Use and Soil Management and Chemical Characteristics of the Soils, in which the present uses of the soils are described, their management requirements discussed and suggestions made for improvement; and (5) Water Control on the Land, in which problems pertaining to drainage and control of runoff are treated.

Readers interested chiefly in specific areas, such as particular locality, farm, or field, include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers, prospective purchasers and tenants, and farm-loan agencies. These readers should (1) locate on the map the tract concerned; (2) identify the soils on the tract by refering to the legend on the margin of the map and seeing the symbols and colors that represent them; and (3) locate in the table of contents under the section of Soils the page where each type is described in detail, giving information on its suitability for use and its relations to crops and agriculture. They will also find useful specific information relating to the soils in the sections on Productivity Ratings, Land Use and Soil Management, Chemical Characteristics of the Soils, and Water Control on the Land.

Students and teachers of soil science and allied subjects, including crop production, animal husbandry, economics, rural sociology, geography, and geology, will find interesting the section on Morphology and Genesis of Soils and Mechanical Analysis. They will also find useful information in the section on Soils and Agriculture, in which are presented the general scheme of classification of the soils of the province and a detailed discussion of each type. For those not familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions and Mechanical Analysis. Teachers of other subjects will find the sections on Description of the Area, Agriculture, Productivity Ratings and the first part of the section on Soils of particular value in determining the relation between their special subjects and the soils of the area.

—Adapted from the U.S.D.A.

ILLUSTRATIONS

TEXT FIGURES

SOIL CLASSIFICATION AND EROSION SURVEY OF MISAMIS ORIENTAL PROVINCE

BY FRANCISCO B. LOPEZ, TEODOMERO M. YÑIGUEZ
AND EDMUNDO K. VILLEGAS
Of the Bureau of Soil Conservation
Department of Agriculture and Natural Resources

ERRATA

Page iii, 1st paragraph, 3rd line from bottom, *that* should be read *and;* 2nd line from bottom, insert *it* between *fact-gathering* and *is.*

Page 19, 4th line from top, *due to* should be read *and.*

Page 27, Table 9, under column *Soil Type, 203* should be read *206.*

Page 60, 6th line from top, the expression should be read *Areas having slopes even greater than 30 per cent are cleared and cultivated, and runoff is rather excessive. Uncultivated portions are in most parts under cogon grass.*

Page 63, 1st paragraph, 2nd line from bottom, *that* should be read *and;* insert *the channels* between *process* and *widen.*

Page 82, 3rd paragraph, 2nd line from top, (*7*) should be read (*43*).

Page 114, *Nos. 6 and 9* are duplications of *Nos. 3 and 4,* respectively.

and little rice land.

The province has a rugged surface. The coast is irregular with high headlands that alternate with bays bordered by sloping lowland in river valleys. The coastal lowland is generally narrow and crossed by many streams; local swampy patches; and short stretches of sandy beach. The upland surface is cut by many gullies, narrow ravines, and canyons which may be 500 feet deep or more and there are numerous sharp angular hills cut by streams in deep gorges.

The general trend of drainage condition is in a northward direction. [illegible], Odiongan, Tagoloan, Cagayan, Ipona, Gingoog, Alubijid, Initao, and Talabaan Rivers drain the province.

The vegetation of the province is four kinds, namely: forest, open grassland, cultivated land, and swamps and mangroves. The higher mountains including slopes are thickly forested and timber construction purposes are abundant. Part of the rolling areas and some of the hills are generally cogonal and the other places are covered with secondary forest. The plains and valleys are devoted to cultivated crops, such as coconut, rice, fruit trees, corn, vegetables, abaca, root crops, etc. The swamps are mostly of nipa palms and mangroves.

The early history of Misamis Oriental is the history of Misamis Province (Misamis Oriental and Misamis Occidental). Later Misamis Province was divided into two provinces, Misamis Oriental and Misamis Occidental. Misamis Occidental constituted all the regions west of Iligan Bay, while Misamis Oriental comprised all the regions east of the Bay, including Camiguin Island. Cagayan de Oro which was the capital of formerly Misamis Province was retained the capital of Misamis Oriental and accorded a Chartered City, inaugurated in August, 1950.

The population of the province was 125,788 in 1918; 213,812 in 1939; and 369,671 in 1948 with an increase of 247,883 or 191.56 per cent from 1918 to 1948.

Transportation and communication facilities are available in the province. Lourdes is the only town not connected to any class of road. As of January, 1948, there is a total of 437.30 kilometers of roads in the province breaking into 188.80 kilometers first class, 183.90 kilometers second class, and 65.20 kilometers third class. Regular bus transportation service is maintained throughout the province by several transportation companies.

The Philippine Airlines Incorporated maintains air transportation facilities in Cagayan de Oro City. Maritima Express Lines and the Manila Steamship Company Incorporated call at Cagayan de Oro and Bugo ports weekly. Small boats and motor boats call also at Cagayan port. Foreign ships dock at these ports once in a while.

Telegraph service is maintained by the Bureau of Posts in Cagayan de Oro City and other towns.

A provincial high school and trade school are found in Cagayan de Oro City. Junior high schools are located in other towns. Elementary schools are maintained in all towns and big barrios. In small barrios, the primary school is in operation. Private schools owned by the Catholic Church and private organizations are found in Cagayan, Gingoog, Mambajao, Talisayan, Initao, and Manticao. Ateneo de Cagayan is the oldest and the biggest of these private schools.

The Bureau of Health maintains a provincial hospital in Cagayan de Oro City. Puericulture centers are organized and operating in most towns. The Philippine National Red Cross has a chapter office in Cagayan de Oro rendering humanitarian work in the province.

Agriculture is the most important industry of the province. Other industries are fishing, lumbering, grazing manufacturing, commerce, weaving, and canning.

Two types of climate based on rainfall distribution occur in the province, viz., the Second Type, and the Third Type or Intermediate Type

The second type with no dry season and with a very pronounced maximum rainfall from October to January occurs in the eastern part of the province. The third type with no very pronounced maximum rain period and a short dry season lasting from one to three months occurs in the central and western parts of the province. The dry months start from February and end in April, while the wet months are from May to January.

The province has a wide variety of crops with coconut and rice as the most important. Coconut occupies practically 75 per cent of the cultivated area. Corn, abaca, bananas, fruit trees, vegetables, root crops, tobacco, and sugar cane are some of the other crops grown.

The farmers employ generally the native plows and harrows as the implements of tillage and the carabaos and cows as the source of power. The change of farm practices from the primitive to more advanced agriculture is rather slow, but there is a trend towards improvement. In recent years, the use of fertilizer in the farms is gaining momentum. Tractors are used in the cultivation of the farms especially in the rolling uplands of Claveria. The primary need of the province is work animals.

The total farm area of the province is 112,661 hectares, 67,233 hectares of which or 17.16 per cent of the total area of the province is cultivated. The census of 1939 shows that of all the farms of the province, 71.56 per cent are operated by owners; 7.61 per cent by part owners, 4.45 per cent by managers; and 21.44 per cent by tenants.

The soils of Misamis Oriental are classified and mapped into three distinct groups based on their relief, namely, (1) soils of the plains, valleys, and undulating areas, (2) soils of the hills, high uplands, and mountains, and (3) miscellaneous land type.

The soils of the plains, valleys, and undulating areas have an area of approximately 55,173.17 hectares or 14.09 per cent of the total area of the province. This group of soils comprises the coastal plains, the valleys in the interior, and the gently undulating areas of the lower uplands. There are six soil types mapped under this group of which Mambajao clay is the largest and devoted principally to coconut. It is also best adapted to the culture of abaca. The other soil types are San Manuel loam, Umingan loam and clay loam, Bantog clay, and Matina clay. These soil types are primarily planted to coconut with rice as the next important crop. They are also suited to the growing of abaca besides the farm crops already grown in them.

The soils of the hill, high upland, and mountains have a total area of [illegible] hectares or 84.35 per cent of the total area of the province. These soils occupy the rolling areas, hills, plateaus, and mountains of the province. Nine soil types and one land type compose this group. They are Jasaan clay, Jasaan clay, stony phase, Jasaan clay loam, Jasaan-Bolinao complex, Lourdes clay loam, Camiguin clay, Bolinao clay, Faraon clay, Alimodian clay loam, and Mountain soils undifferentiated. Of these soil types, Jasaan clay is considered the most important as regards to agriculture. It is devoted principally to coconut, abaca, and upland rice. Most of these soils have been depleted due to erosion and in some areas are already submarginal to all kinds of food crops.

The hydrosol and the beach sand are mapped under the soils of the miscellaneous land type. These are found mostly on the coastal regions bordering the sea with a total area of 6,107.62 hectares or 1.56 per cent of the total area of the province.

The soils of Misamis Oriental are primary and secondary soils and their parent materials have different physical and chemical composition. On the basis of topography, mode of formation, and kind of profile, the soil series in the province are grouped into six profile groups, namely, Profile groups I, II, III, VII, VIII, and IX.

Productivity ratings of the various soil types on the important crops grown in the province are shown in Table 11. These ratings were obtained on the basis of the average yields of crops where farm practices do not include the use of commercial fertilizers or amendments. The most productive soils are the San Manuel loam, Umingan loam, Bantog clay, Mambajao clay, Matina clay, and Jasaan clay.

Table 11 also shows the relative physical land classification of the soil types for use into first-, second-, third-, fourth-, and fifth-class soils. Its ultimate purpose is to provide information on the relative physical adaptation of various soils on the present set-up of agriculture in the province.

Ordinarily, the first-, and second-class soils do not have slopes more that 5 per cent and are not affected much by runoff and resulting erosion. The third-, fourth-, and fifth-class need special agricultural practices for the regulation of runoff and certain mechanical means of controlling erosion.

I. SOIL SURVEY OF MISAMIS ORIENTAL

The report and the accompanying maps in pocket present the Reconnaissance Soil Survey and the Erosion Survey of Misamis Oriental Province conducted from February 11 to May 30, 1950 inclusive. The information herein may familiarize various persons who are interested particularly on the soils, the crops, the agriculture, the management, and the soil erosion of the region and/or for reference on future work on scientific researches and investigation of the soil of the province.

INTRODUCTION

This part of the report includes the discussion on: (1) the description of the area particularly the location and extent, geology, relief, drainage, vegetation, history, population, transportation, cultural features, and industries; (2) the climate, with emphasis on rainfall, temperature, relative humidity, winds, and including the climatological data of the province; (3) agriculture, discussing the brief history and the present agricultural status of the province, including crop statistics, agricultural practices, livestocks and livestock products, land use changes,

farm tenure, and type of farm; (4) the soils, describing in detail each soil type with a discussion of their agricultural importance; (5) productivity ratings, presenting in table form the productivity ratings of each of the soil types and grouping the soil types according to their relative physical suitability for agriculture; (6) land use and soil management, discussing the present uses of the soil types, their management requirement, and giving suggestions for their improvement; and (7) the colored soil map in pocket showing the location and distribution of the different soil types classified in the province.

GENERAL DESCRIPTION OF THE AREA

Misamis Oriental, one of the provinces of Mindanao Island, is located on the northern part (Fig. 1). It is bounded on the north by the Mindanao Sea, on the east by Agusan Province, on the south by Lanao and Bukidnon Provinces, and on the west by Iligan Bay. It has an area of approximately 3,916.81 square kilometers, or 391,681 hectares, including Camiguin Island. Cagayan de Oro City is the capital of the province and is 475 air miles from Manila. It can be reached either by boat or by plane from Manila. The actual soil cover is found in table 1.

TABLE 1.—*Approximate area of the actual soil cover of Misamis Oriental Province as of June 30, 1946*[1]

KIND	Area in hectares	Per cent
Commercial forest	166,760	42.58
Non-commercial forest	69,841	17.83
Swamps (Fresh marsh and mangroves)	1,140	.29
Open land	86,707	22.14
Cultivated land	67,233	17.16
TOTAL	391,681	100.00

[1] Data from Yearbook of Philippine Statistics, 1946.

Along the coast of the province, especially in the eastern part are Recent coral reefs which are partly exposed at low tide. The hills along the coast and the rolling areas above the coastal plains are of Tertiary sedimentary rocks such as limestone, sandstone, conglomerates and limy shales. Igneous rocks, mostly intermediate to basic flows with some agglomerate and ash beds, compose the higher uplands, hills and mountains, and that of Camiguin Island. Undifferentiated metamorphic rocks such as schist, slate, gneiss, and quartzite are present in the hilly regions and mountains of Lourdes and Lumbia.

The province is rather mountainous. In the majority of cases, however, the mountains are below 1,000 meters above sea level. Mt. Mapua is the highest mountain in the mainland, being 1,480 meters above sea level. Camiguin Island, which is a part of the province and lies about 5 miles off Sipaca, has steep, wooded volcanic mountains rising to more than 1,527 meters with slopes and narrow coastal lowland covered with abaca and coconut plantations and a little wet rice land. Mt. Mambajao and Mt. Sinablayan in this Island are 1,713 meters and 1,921 meters high respectively. Mt. Hibok-hibok is an active volcano in Camiguin Island. It erupted in 1948 before the soil survey was conducted, also in September, 1950 and July, 1951 after the soil survey of the province.

Misamis Oriental has a rugged surface (Fig. 2). In the eastern part are sharp angular hills cut by streams in deep gorges. The coast is irregular with high headlands that alternate with bays bordered by sloping lowland in river valleys. In the central part, the upland surface is cut by many gullies, narrow ravines, and canyons which are 500 feet deep or more. The upland descends abruptly in a rough escarpment to narrow coastal lowlands which are less than two miles in width. The Balingasag-Lagonglong and the Cagayan lowlands are the widest. Mangrove swamp is wide in Cagayan de Oro. In the western part, the rough upland and hills rising abruptly from the sea have altitudes of 1,500 to 2,000 feet. Most of the upland is sharply cut by valleys, narrow ravines and gullies. The coastal lowland is generally narrow and crossed by many streams; local swampy patches and short stretches of sandy beach are component parts.

The general trend of drainage condition of the province is in a northward direction. The eastern part is drained by the Linugos, Odiongan, Ginggoog, and Lonao Rivers; the central section by the Balatucan, Cabulig, Tagoloan, Agusan, Cagayan, and Ipona Rivers; and the western part by Alubijid, Initao, and Talabaan Rivers. Fig. 3 shows the physiography and relief of the province.

The higher mountains including slopes are thickly forested, and timbers for construction purposes are in abundance. Some hills are covered by second-growth forest, but cogon is the dom-

Fig. 2.—A portion of the rolling lands of Misamis Oriental showing rugged surface. This kind of relief occupies a big area in the province.

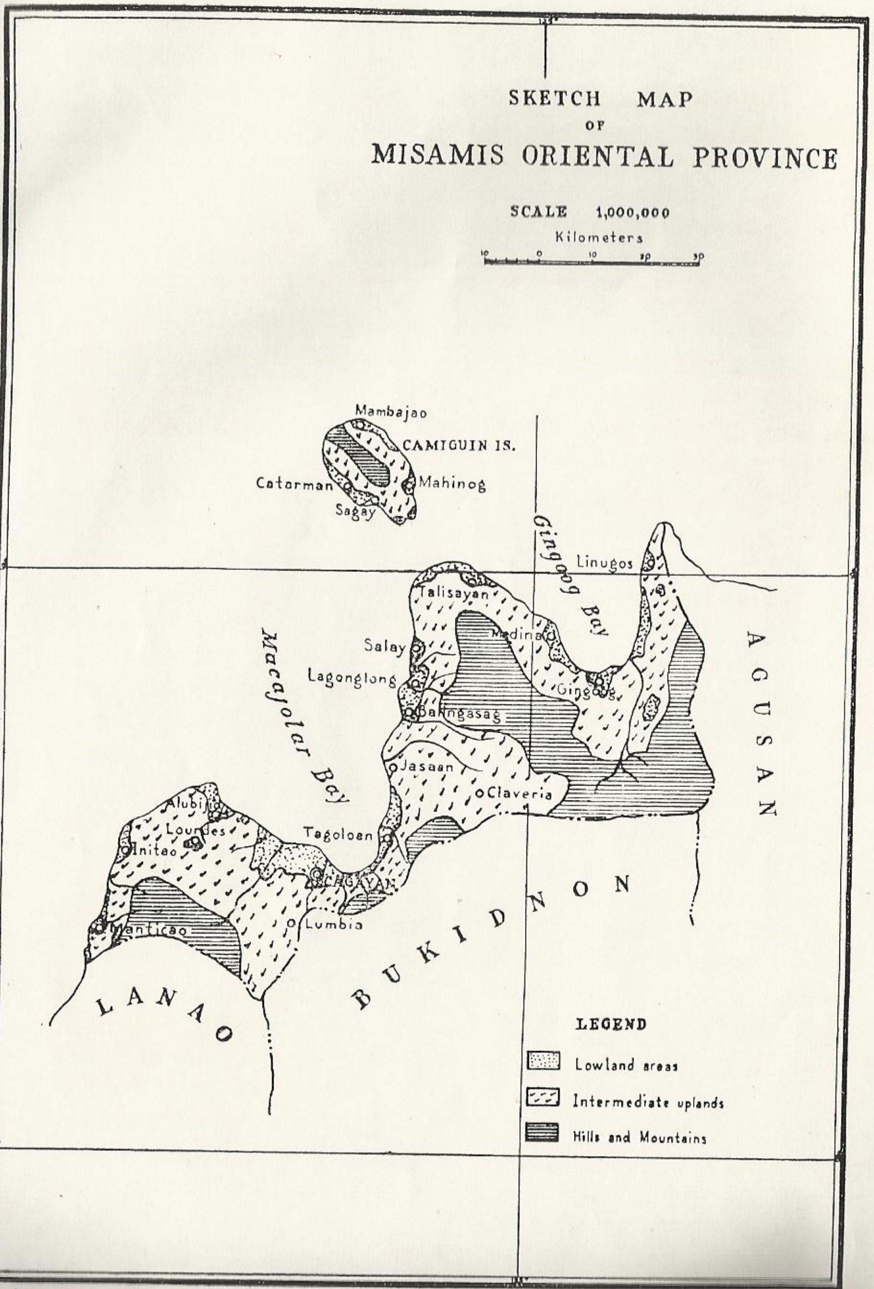

Fig. 3.—Sketch map of Misamis Oriental Province showing general topography and natural drainage system.

nant cover. The higher fiat uplands and the rolling areas inland are cogonal. Hills and the rolling areas along the coast are planted extensively to coconut and in some cases to ipil-ipil or bananas. The plains and valleys are devoted to the growing of rice, corn, tobacco, abaca, root crops, fruit trees, vegetables, bananas, and coconuts. The swamps and marshes are covered with nipa palms and mangroves of different species. These are mostly located near the mouth of big rivers and along the protected small bays.

The early history of Misamis Oriental is the history of Misamis Province (Misamis Oriental and Misamis Occidental). The region was a part of the Kingdom of Corralat, a Mohammedan king of Mindanao. It was ruled by Lord Salanpangm, a vassal to the king.

In 1622, Spanish missionaries whose leaders were the Recollects landed near the present site of Cagayan de Oro and began christianizing the natives. At first they were not molested, but when King Corralat heard of their presence, he took steps to drive them away by force from his territory. Lord Salanpangm, the vassal to the king became a convert to Christianity and protected the missionaries. He made a strong fortification of Cagayan against King Corralat, so that the missionaries finding safety in the place, built their convent which they made the center of their missionary work in the region.

Bukidnons were the first inhabitants of Misamis. The inflow of immigrants into the province from the Visayan Islands, particularly from Bohol and Cebu, compelled the Bukidnons to withdraw to the interior. To the present date, Bukidnon, as a tribe, is lost in the province.

In 1818, Misamis gained the status of a province. It was composed of four district divisions called "Partidos," namely, (1) Partido de Misamis, included under it were the Ports of Misamis and Iligan, in addition to Loculan and Initao; (2) Partido Dapitan, composed of Dapitan, Lobungan, and some villages; (3) Partido de Cagayan, including Cagayan, Ipona, Molugan, Jasaan, and Salay; and (4) Partido de Catarman, which is the whole Island of Camiguin.

In 1850, Misamis Province became one of the four political divisions of Mindanao. A large portion of Lanao, all of Bukidnon, and the northern portion of Cotabato were included in its jurisdiction.

During the later part of the Spanish rule Mindanao was made into seven districts. Misamis Province became one of these districts with Cagayan, now Cagayan de Oro as the capital. In December, 1899, Misamis Province came into the hands of the Revoluntionary Government, but three months later it was captured by the Americans.

On May 15, 1901, civil government under the American regime was established. The subprovince of Bukidnon was included in its jurisdiction. In 1907, Bukidnon was given to Agusan Province.

Later on, Misamis Province was divided into two provinces, viz., Misamis Oriental and Misamis Occidental. All the regions west of Iligan Bay composed Misamis Occidental and all the regions east of the Bay including Camiguin Island constituted Misamis Oriental. Cagayan de Oro was retained the capital of Misamis Oriental and was converted into a chartered city, inaugurated in August, 1950.

The population of Misamis Oriental in 1918 was 125,788; in 1939, 213,812; and in 1948, 369,671. The increase of population from 1918 to January 1939 was 88,024 or 69.9 per cent, and from 1939 to 1948 was 155,859 or 72.8 per cent. But the increase of population from 1918 to October, 1948, was 243,883 or 193.8 per cent.

The towns of Misamis Oriental except Lourdes are connected with either first, second, or third class roads. The capital is connected to Bukidnon, Agusan, and Lanao Provinces by a national road. As of January, 1948, the province had a total of 437.30 kilometers of roads, 188.80 kilometers of which is first class; 183,90 kilometers, second class; and 65.20 kilometers, third class.

There are several private transportation companies operating in the province, some of which are the International Bus Company, Mindanao Bus Company, Maria Cristina Bus Company, and the Republic Transportation Company.

The Philippine Airlines Incorporated maintains air transportation facilities in Lumbia, Cagayan de Oro connecting it with Manila and other airports of the country. Air service is daily except Sunday. Boats of the Maritima Express Lines and the Manila Steamship Company Incorporated, besides small boats and motor boats for inter-island travel, call at Cagayan de Oro and Bugo ports. The Maritima and Manila Steamship

boats call once a week. Foreign ships dock also at these ports once in a while.

There is a telephone system operating in the province connecting Cagayan de Oro with nearby towns. Telegraphic stations are located in Cagayan de Oro, Gingoog, Mambajao, and some other towns.

The Bureau of Public Schools maintains a provincial high school and a provincial trade school in Cagayan de Oro and junior high schools in other towns. It also maintains elementary schools in all towns and big barrios besides the primary schools in small barrios. Private schools run by the Catholic Church and private organizations are found in Cagayan de Oro, Gingoog, Mambajao, Talisayan, Initao, and Manticao. Some of these private schools offer collegiate courses besides the elementary and secondary courses. Ateneo de Cagayan and Lourdes College are the biggest and oldest colleges in the province offering collegiate courses.

The Bureau of Health looks after the individual and community health through the Puericulture Centers organized in most towns. The provincial hospital is located in Cagayan de Oro. The Philippine National Red Cross has a chapter office in Cagayan de Oro, rendering humanitarian work in the province.

Agriculture is the most important industry in the province. Fishing is confined mostly to the towns along the shores. There is no fishpond in the province for the culture of milkfish. Most of the fish is caught in the open sea.

Lumbering is another important industry in the province. Table 2 gives the daily capacity, area of concession, and investment or capital of each sawmill in the province. At present there are four big sawmills with a total daily capacity of from 13,500 to 54,000 board feet and a total investment of ₱1,616,000.

Grazing used to be a profitable industry before World War II. During the Japanese occupation, this industry was practically wiped out and has not been rehabilitated as yet.

Trade and commerce are becoming important industries in the province. The ports of Cagayan de Oro and Bugo, besides the secondary ports of Balinguan, Medina, Mambajao, and Gingoog are the main ports of the province. Bukidnon Province uses Cagayan de Oro and Bugo ports as the outlet of its products. Cagayan de Oro and Gingoog are the centers of trade and commerce in the province.

The pineapple cannery of the Philippine Packing Corporation is located in Bugo. Hats, mats, slippers, and ice cream manufacture, salt making, nipa thatching and weaving are the household industries.

TABLE 2.—*Sawmills, their location, daily capacity, area of concession, and investment in Misamis Oriental Province*[2]

Name of sawmill	Location	Daily capacity	Area of concession	Investment or capital
		Bd. Ft.	Ha.	Pesos
1. Willkom Sawmill	Tood, Cabalantian, Lourdes, Mis. Or.	1,500 to 2,500	7,150	26,000.00
2. Claveria Sawmill	Luna, Claveria, Misamis Oriental	6,000 to 7,000	1,000	90,000.00
3. Sta. Clara Lumber Co. Inc.	Lunao, Samay, Gingoog, Mis. Or.	12,000 to 17,000	6,132	500,000.00
4. Anakan Lumber Company	Anakan, Gingoog, Misamis Oriental	24,000 to 28,000	36,939	1,000,000.00

[2] Data furnished by the Office of the Provincial Forester, Cagayan de Oro, Misamis Oriental.

CLIMATE

Climate is one of the primary factors of soil formation. Besides its direct effect on the weathering of rocks, it plays no small part in affecting the characteristics of soils especially over broad areas. In combination with the natural vegetation, it is the force largely responsible (there are other factors besides) in bringing into existence the general pattern of soils. The kinds of vegetation and the predominant vegetation influence the quantity and quality of organic matter for soil building and in turn the decay and the rates of biological and chemical changes of organic matter depend primarily on temperature and moisture. The combination of these effects determines to a great degree the characteristics of a given soil.

The kind of natural vegetation is also determined by the climate of a place. In like manner the agricultural pattern is strongly subject to climatic influence including erosion hazards. There appear many different types of plants as a consequence of the climatic influence under which they have been long exposed. Many species of plants have been eliminated because of

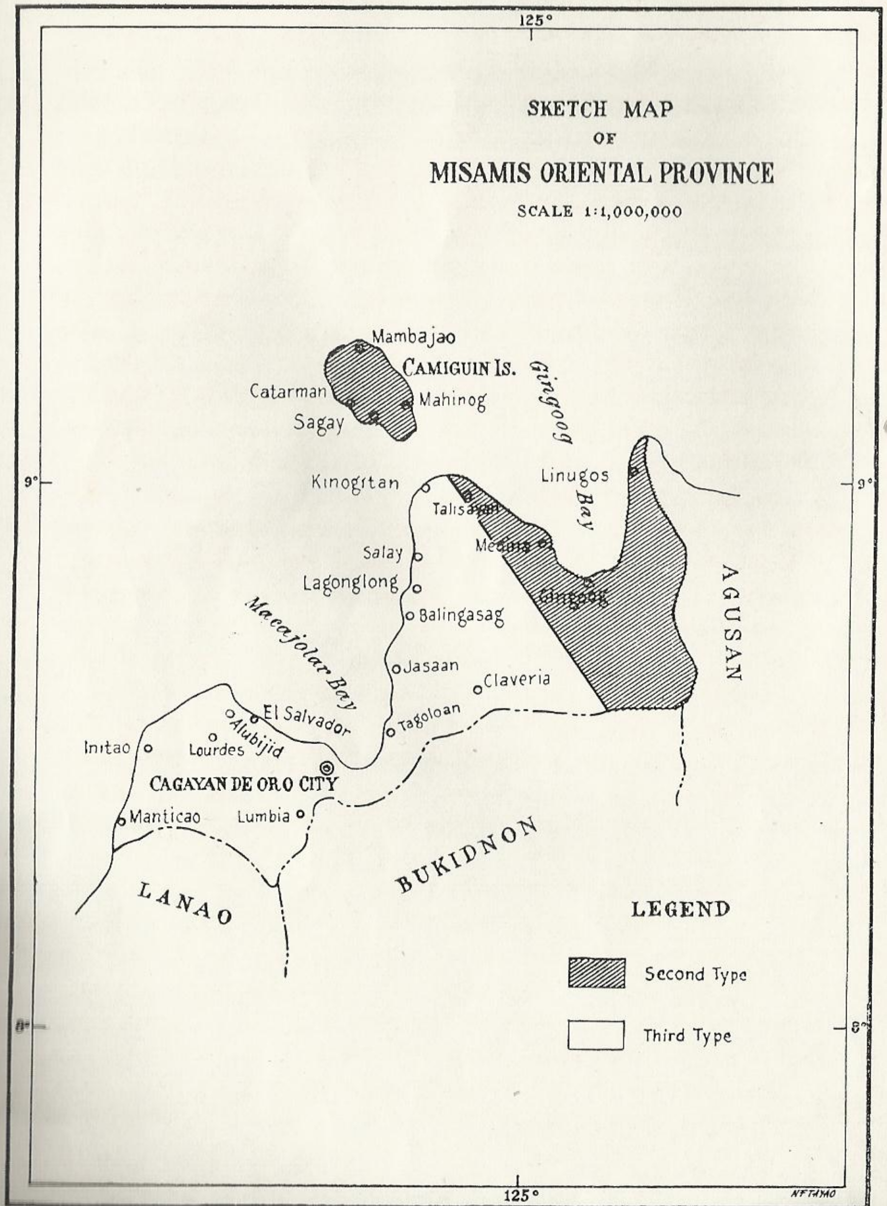

Fig. 4—Sketch map of Misamis Oriental showing the areas under the two types of climate.

non-adaptation to climate, and many types of plants have adjusted themselves to a wide climatic condition. On the other hand, man may change agricultural practices according to his needs and habits, but these are subject within the limits of climatic condition. In some cases, agricultural production is a failure because climatic consideration is not fully and adequately regarded, so much so when we take into account that "an area in general is especially suited by climate and soil to produce what it does." The differences in natural landscape that accompanies one climatic region to another can be explained in part by the result of erosion activities due to water, wind, and other agents which share in the shaping of the land surface.

Land use capabilities, industries, health, and land settlement are also within climatic limit. Under these considerations the climate of a place should receive adequate recognition in the planning of agricultural projects.

Misamis Oriental has two types of climate based on rainfall distribution in the Philippines, the second type and the third type, or Intermediate type A. They occur in two regions (Fig.4). The second type is characterized by a very pronounced maximum rainfall from October to January and no dry season. This type of climate occurs in the eastern part of the province, from Quinoguitan to the boundary of Agusan Province, including Camiguin Island. Normally under this type, rainfall is fairly well distributed throughout the year and sufficient for all the crops. While the agricultural pattern of the whole province is the same, agricultural practices under this type of rainfall can be so modified as to carry out an intensive cultivation of the land. In other words, this region is adapted to crop diversification and a sound program of crop rotation may be adopted as one of the best uses of the land in this region. Crops such as durian, lanzon, and abaca are planted commercially in this region but are not found commercially in other parts of the province.

The third type, or intermediate type A, has no very pronounced maximum rain period with a short dry season lasting only from one to three months. This type of rainfall occurs in the central and western parts of the province. The dry months usually start from February and end in April, while the wet months are from May to January. The lands under this type are adapted to a wide variety of farm crops but can not, however, be intensively cultivated as to make the lands fully diversified. This is because besides the 3 months of dry season the precipitation is rather low in comparison with that of the second type as shown in table 3. Agricultural practices under the two types of rainfall are somewhat slightly different, being influenced and modified by the existing climatic conditions.

Table 3 gives the average monthly and annual rainfall and the number of rainy days of each month of the year for the two types of climate in the province. Mambajao weather station represents the second type while Cagayan de Oro and Balingasag weather stations represent the third type. The second type has a greater precipitation and more rainy days than the third type. The mean annual rainfall in Mambajao is 2461.7 millimeters which is 858.4 millimeters and 802.2 millimeters more than those of Cagayan de Oro and Balingasag, respectively. It has also 168.8 rainy days which is 40.5 days and 47.2 days more than those of Cagayan de Oro and Balingasag, respectively.

The average monthly normal temperature and the extreme of temperatures for Cagayan de Oro are shown in table 4. April and May are the hot months; December, January, and February are the cold months. Differences in temperature within the province are caused by differences in elevation. The mountain regions and the higher uplands bordering Bukidnon and Lanao Provinces have lower temperatures than the coastal regions. Figs. 5 and 6 show the graphs of the climatic elements of the second and third types of climate.

TABLE 3.—*Mean monthly and annual rainfall and number of rainy days in Misamis Oriental*[3]

Month	Third type of rainfall				Second type of rainfall	
	Cagayan de Oro 4		Balingasag 5		Mambajao 6	
	Rainfall	Rainy days	Rainfall	Rainy days	Rainfall	Rainy days
January	96.1	9.3	75.2	7.0	385.1	19.9
February	58.1	6.2	51.7	6.8	165.8	11.9
March	35.1	4.9	25.6	2.7	140.8	11.6
April	28.3	3.8	21.3	2.5	52.7	6.8
May	111.2	10.5	47.8	10.0	114.2	9.8
June	221.1	16.2	177.8	18.0	148.9	13.0
July	215.2	14.8	241.0	13.4	191.6	14.6
August	193.8	14.3	179.0	12.4	140.5	12.3
September	212.1	14.5	274.4	12.8	173.9	12.9
October	202.5	13.9	225.9	15.4	306.0	17.5
November	117.9	9.3	253.6	10.4	265.2	18.1
December	111.9	10.2	86.2	10.2	377.0	20.4
Mean annual	1,603.3	127.9	1,659.5	121.6	2,461.7	168.8

[3] Selga, Miguel, S.J. Observation of Rainfall in the Philippines. Weather Bureau, Manila (1953) 1-289

[4] 25 Years (1909-1933)

[5] 6 Years (1902-1907)

[6] 17 Years (1917-1933)

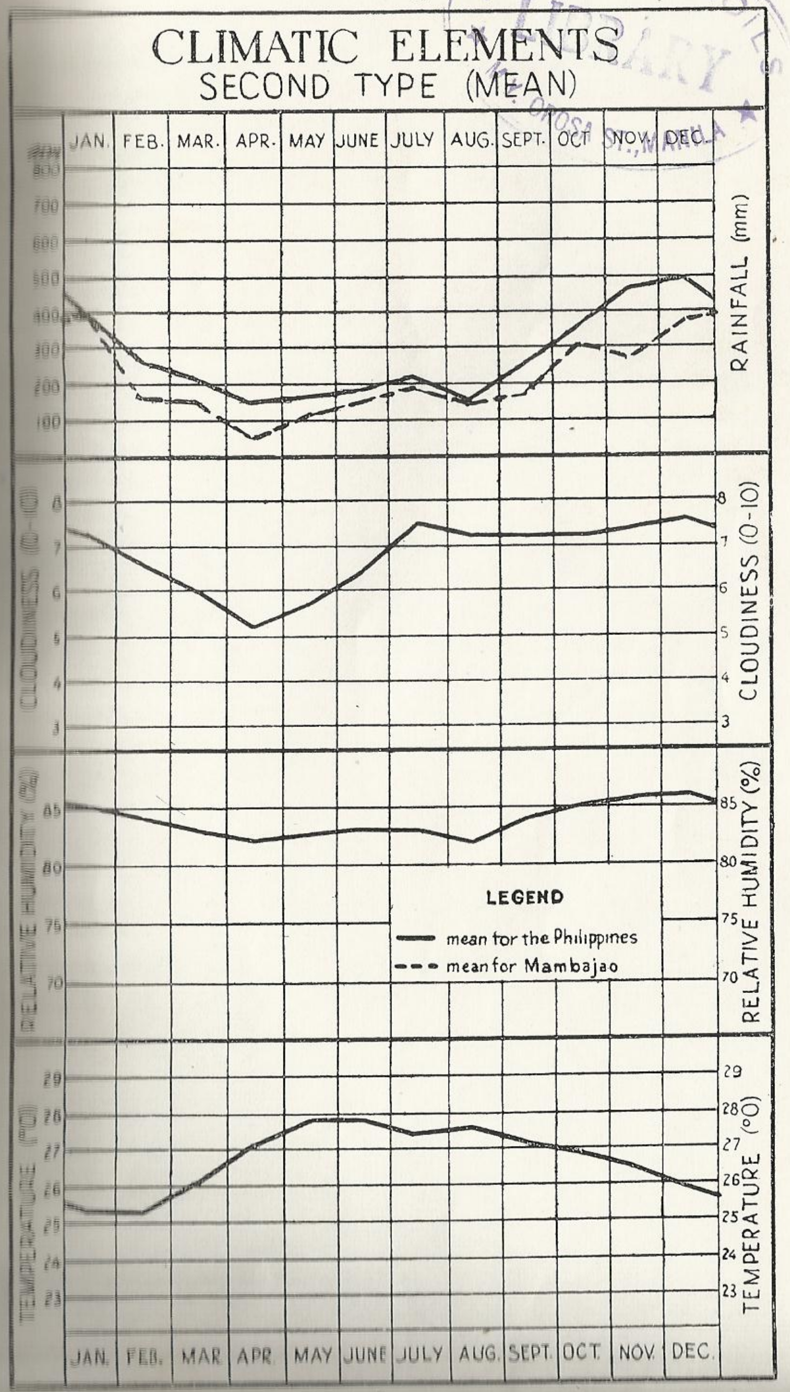

Fig. 5.—Graph of the second type of climate of the Philippines and of Mambajao, Misamis Oriental.

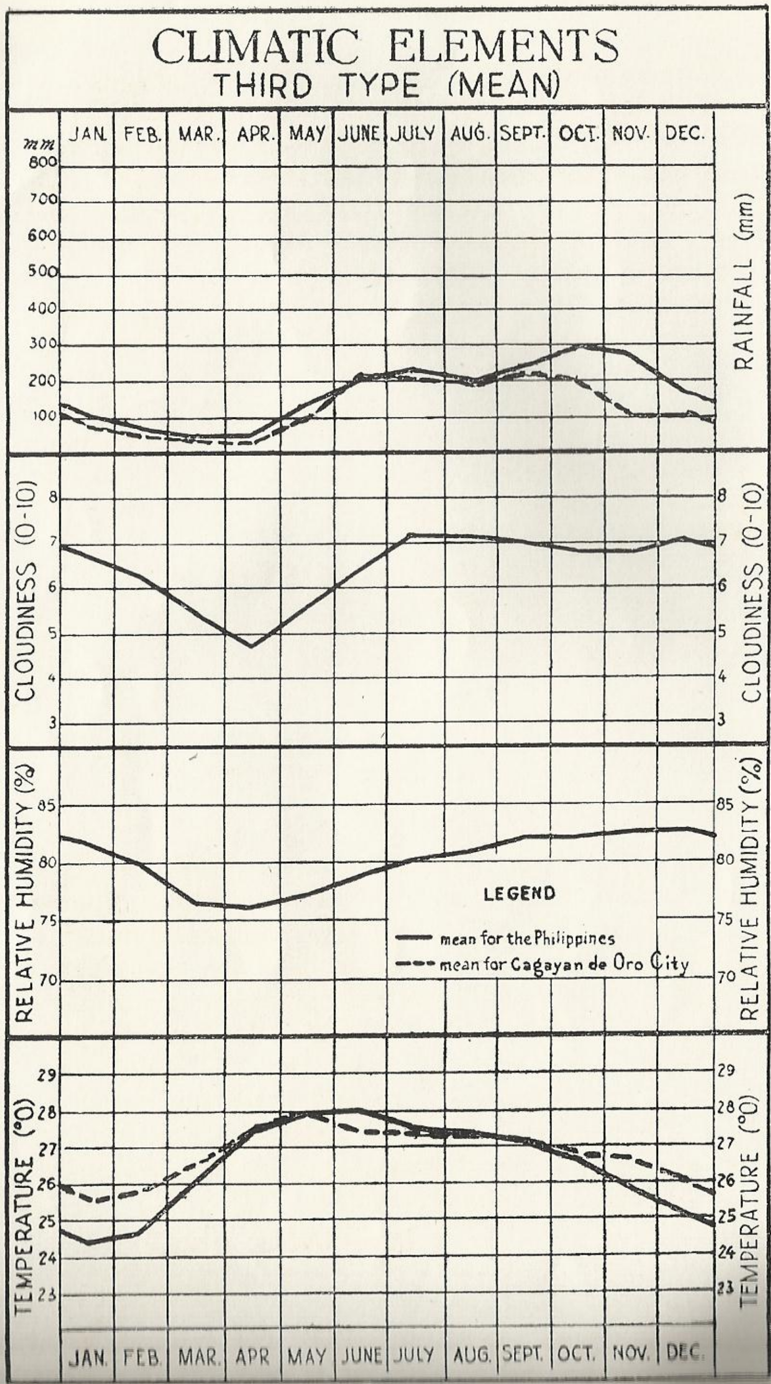

Fig. 6.—Graph of the third type of climate of the Philippines and of Cagayan de Oro City.

The relative humidity is similar to that of Surigao. It ranges from 79 per cent to 86 per cent. The prevailing winds during the months from May to November are those from NE-ENE and E-ESE, while from June to October are those from SW-WSW. The province is below the typhoon belt and there has not been any remarkable or destructive typhoon that occurred in the province.

TABLE 4.—*Average monthly normal temperature and the extremes of temperature for Cagayan de Oro, Misamis Oriental* [7]

Months	Maximum temperature	Normal temperature	Minimum temperature
	° C	° C	° C
January	31.6	25.6	18.9
February	32.4	25.8	18.5
March	33.5	26.5	19.4
April	34.2	27.5	20.4
May	34.2	28.0	21.5
June	33.9	27.4	21.4
July	34.7	27.3	21.1
August	34.4	27.3	21.1
September	34.5	27.2	21.1
October	33.8	26.8	21.3
November	32.9	26.6	20.5
December	32.2	26.0	19.4
Mean annual	33.4	26.8	20.4

[7] Rev. Jose Coronas. The Climate and Weather of the Philippines.

AGRICULTURE

Agriculture is the leading industry of the province. It is believed that this industry began long before the first Spaniards landed in the region. The 1949 "Facts and Figures of the Philippines" show that the potential area available for agricultural, industrial and other purposes after the timber is cut is 249,932 hectares. The total estimated area cultivated for the same year for the different farm crops and fruit trees was 75,460 hectares with the total value of the produce amounting to ₱24,891,950. Table 5 shows the area, production, and value of the ten leading crops of the province in 1949 arranged in the order of hectarage.

Coconut. — This is the most important crop and most extensively grown in the province. It is widely planted especially along the shore, irrespective of whether the land is level lowland, flat upland, rolling or hilly. It grows well from sea level to as high as 1,200 feet above sea level (Fig. 7). The climate of the province is most favorable to the culture of coconut.

In 1949, the area devoted to coconut was 36,630 hectares and the value of the produce was ₱17,377,720. The most important products derived from coconuts in the province are copra, oil, and tuba. About 250 nuts make a picul of copra. Sun-drying (Fig. 8) and smoke-drying or "tapahan" are the two common methods of copra making in the province. Incidentally, these two methods are the common methods used in the Philippines. The soil types of Misamis Oriental where coconut grows best are Mambajao clay, Matina clay, San Manuel sandy loam, Faraon clay, Bolinao clay, Camiguin clay, Jasaan clay, and Umingan sandy loam. The five leading towns growing coconut are Gingoog, Talisayan, Cagayan de Oro City, Initao, and Mambajao. Misamis Oriental is among the leading coconut producing provinces of the Philippines.

TABLE 5.—*Area, production, and value of the important crops of Misamis Oriental*[8]

Kind of crop	Area in hectares	Production in kilograms	Value in pesos
Coconut:	36,630		
Copra		46,462,000	17,177,620
Food nuts		1,766,000	169,600
Home-made oil		30,230	32,500
Corn (shelled)	20,900	14,295,600	2,633,400
Rice (rough)	5,090	5,853,760	1,663,000
Camote (sweet potato)	2,390	5,540,900	554,090
Abaca	2,300	1,150,000	460,000
Tobacco	300	165,230	148,710
Gabi	300	600,000	60,000
Cassava	140	294,000	13,700
Ubi	90	180,000	18,000
Sugar cane	60		
Muscovado and panocha		94,000	28,300
TOTAL	68,200	76,431,720	22,958,920

[8] Facts and Figures of the Philippines. Bureau of the Census and Statistics, (1948-1949).

Corn. — Paradoxically, corn (Fig. 9) is second to coconut as the leading crop of the province while rice is the staple food of the people. This is not because the majority of the people prefer the planting of corn, but because the physiographic condition of the land is much more suited to the extensive planting of corn than rice. In 1949, the area planted to corn was 20,900 hectares with a total production of 14,295,600 kilos valued at ₱2,633,400.

Corn is generally planted twice a year in Misamis Oriental. The first planting is from May to June and harvested in August to September, while the second crop is planted in October and

Fig. 7.—Coconut trees are planted in level lands and hilly areas along the shore. This crop has the largest area planted in the province.

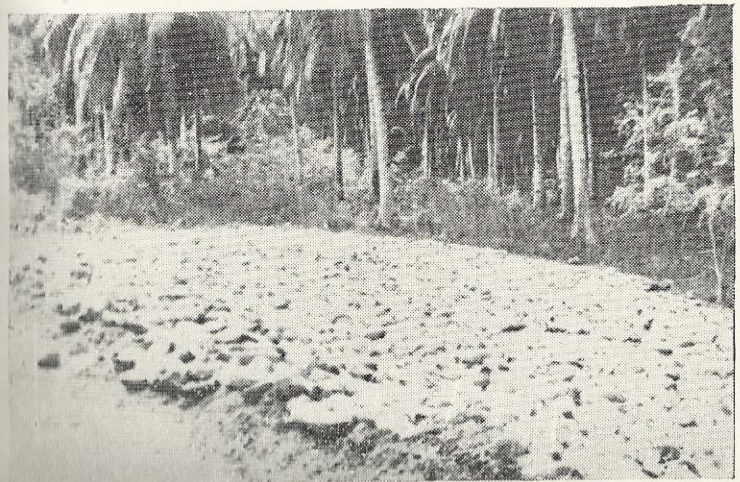

Fig. 8.—One of the common methods of curing copra in the province is sun-drying. The picture above shows nuts divided into halves and put under the sun for drying.

Fig. 9.—Corn is the second important crop of the province as regard to area planted. The picture above is a corn field on Jasaan clay taken in Claveria of about 2,500 feet elevation.

November and harvested in January and February. The varieties planted are the Yellow and White Flints. It is planted on all the soil types mapped in the province but grows best on Mambajao clay, Jasaan clay, San Manuel sandy loam, and Umingan sandy loam soils. Production to the hectare ranges from 8 cavans to 26 cavans.

Rice.—Next to corn in area is rice. This crop constitutes the main food of the people in Misamis Oriental. The production of the province in rice, however, is not enough for its population and thus it imports rice yearly from other provinces to cover up the deficiency. The total area planted to this crop in 1949 was 5,090 hectares which produced 5,853,760 kilos valued at ₱1,663,000. Rice is planted both in the upland and the lowland. The leading towns producing rice are Claveria, Gingoog, Balingasag, and Talisayan.

Two groups of rice varieties are planted in Misamis Oriental; the lowland rice varieties and the upland rice varieties. The lowland rice varieties planted are Apostol, Elon-elon, Guinangang, Esmerismis, Calamyon, and Dahili. These are planted on lowland areas which are irrigated or which are entirely dependent on rain for water. Under normal conditions these rice varieties give an average yield of from 30 to 55 cavans of palay to the hectare. San Manuel sandy loam, Umingan sandy loam Umingan clay, Bantog clay, and Matina clay are the soil types generally devoted to lowland rice in the province.

The upland rice varieties are Cayatan, Speaker, Dalaog, San Pablo, Romero, Lubong Pute, Bulaonan, and Dumali. Cayatan gives the highest production for each hectare, which is 70 cavans, and Dumali gives the lowest production, which is 26 cavans a hectare. Jasaan clay, Mambajao clay, Bolinao clay, Jasaan clay loam, Alimodian clay loam, and Lourdes clay loam are the important soil types planted to upland rice. In Claveria, the growing of upland rice is partly mechanized. The production is as high as 70 cavans a hectare. This high production may be due to the fact that the land is newly opened. Besides, the climate is favorable to upland rice.

Abaca.—Of the ten leading crops of Misamis Oriental, abaca (Fig. 10) ranks fifth in area. The area planted to this crop in 1949 was 2,300 hectares, which was 50 per cent less than the total area devoted to it in 1939. The decrease in area may be explained as the adverse effect of the last war. Most of the abaca fields before World War II were either abandoned and have not been rehabilitated or they have been converted to upland rice and corn fields. The value of the total produce in 1949 was ₱460,000 as shown in table 5. Claveria, Mambajao, Salay, Balingasag, and Gingoog are the leading abaca-producing towns of the province. The yield for each hectare of abaca (Fig. 11) ranges from 7 to 30 piculs. Maguindanao, Bongolanon, and Tangongon are the principal varieties planted. The important soil types devoted to abaca are Mambajao clay and Jasaan clay.

Two of the basic requisites for good growth of abaca are suitable soil and climate. The climate of the eastern section of the province is most favorable to the culture of abaca. Rainfall is evenly distributed throughout the year, a condition which gives sufficient moisture for the need of the plants. The soils of this section of the province as described elsewhere in this report are suited to the crop. Besides there is no abaca mosaic in the province, unlike in Davao. Given therefore the proper encouragement and good facilities, Misamis Oriental may yet become one of the best abaca producing provinces of the country. She has all the bright prospects of contributing a big share in the rehabilitation of the abaca industry. She has good ports in Cagayan de Oro City and Bugo as outlets for the crop.

Tobacco. — This crop is planted for home consumption and the local market. There were 300 hectares planted to tobacco in 1949 with a production of 165,230 kilos which was valued at ₱148,710. The average yield for each hectare of tobacco leaves in the province is 11 quintals or 550 kilograms. San Manuel sandy loam, Bolinao clay, Jasaan clay, and Bantog clay are used for the planting of tobacco in the province.

Sugar cane. — Like tobacco, sugar cane is grown for home consumption and the local market. The stalks are sold locally for chewing or milled in the local wooden sugar mill for the production of muscovado sugar and "panochas." The total value of the produce in 1949 for muscovado sugar and panocha was ₱28,300. Claveria and Cagayan de Oro City are the important towns producing sugar cane in the province. Jasaan clay, Mambajao clay, San Manuel loam, Jasaan clay loam, and Lourdes clay loam are the soils generally planted to sugar cane.

Other crops; Root crops. — These crops constitute the important secondary food of the people in general and the main

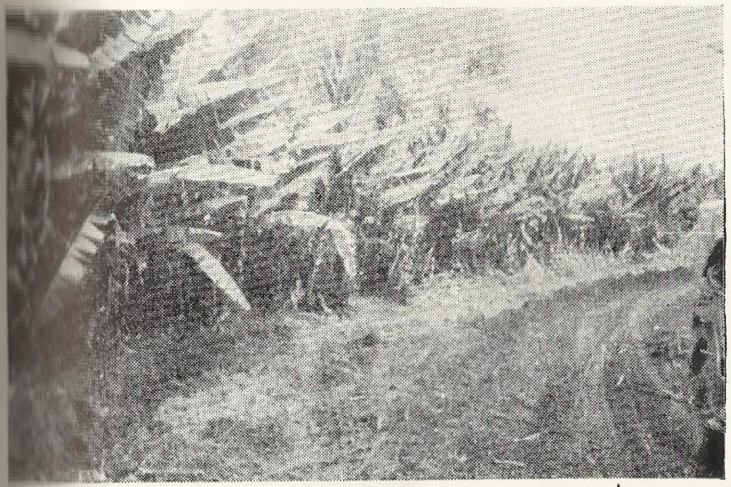

Fig. 10.—Abaca plantation on Jasaan clay taken in Claveria of about 2,500 feet elevation. This is one of the ranking crops of the province. The plantation is not well taken care of.

Fig. 11.—Abaca fiber extracted from the abaca plant. Production of this crop in the province is from 7 to 30 piculs to the hectare.

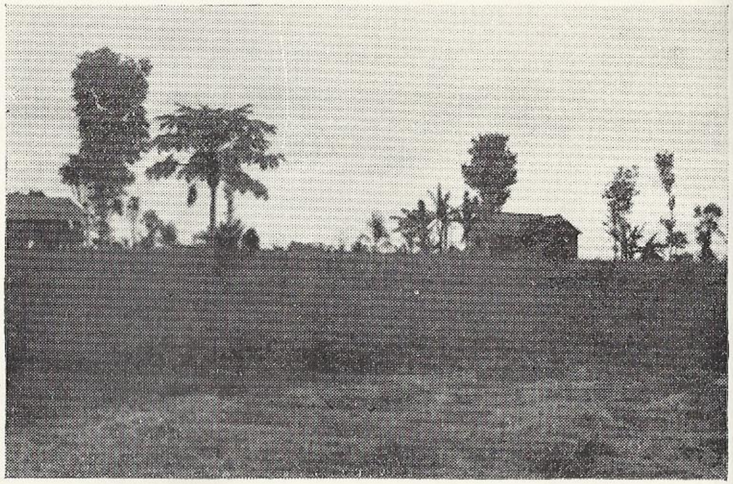

Fig. 12.—Sweet potato is a leading root crop of the province. This picture shows the crop planted to Mambajao clay in Gingoog.

Fig. 13.—Native onion planted to Jasaan clay in Claveria. The elevation of the area is about 2,700 feet above sea level.

PLATE 5

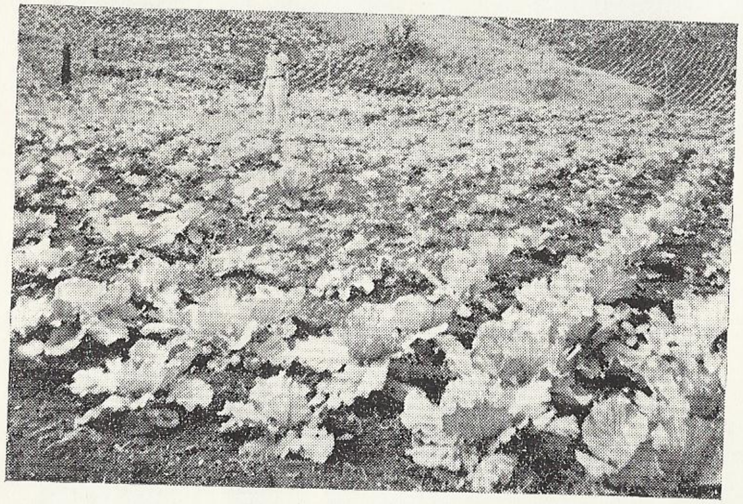

Fig. 14.—Portion of a cabbage truck garden in Luna, Claveria. The elevation of the place is 2,800 feet above sea level. Courtesy of Mr. and Mrs. Pablo Bagoñgon.

food of the mountain people in particular. The area devoted to these crops in 1949 was 2,720 hectares and the produce was valued at ₱646,790.

Camote (sweet potato) is the leading root crop (Fig. 12). Of the 2,720 hectares planted to root crops in 1949, camote occupied an area of 2,390 hectares and the value of the produce was ₱554,090. Gabi is second in importance. Cassava, ubi, and native onion (Fig. 13) arranged in their order of importance are the other root crops of the province. San Manuel loam, Umingan loam, Mambajao clay, Jasaan clay, and Jasaan clay loam are devoted to root crops.

Leguminous crops.—The leguminous crops are planted in small and scattered areas. They are sometimes planted in rotation with corn and upland rice. The 1949 "Facts and Figures of the Philippines" gave 90 hectares as the area planted to these crops of that year with a total production of 44,000 kilos valued at ₱15,020. Peanut is the most important of these crops. The other legume crops planted are sitao, cowpeas, patani, batao, and soybeans.

Vegetable crops.—Of the vegetable crops, cabbage is the most important, being planted in truck gardens (Fig. 14). It is mostly planted in Luna, Claveria with an elevation of 2,850 feet above sea level on Jasaan clay. This region can be favorably compared to that of Trinidad Valley of Baguio for the growing of cabbage. The fields are not fertilized. In 1949, the area planted to cabbage was 40 hectares with a total production of 220,000 kilos and the value of the produce was ₱154,000. Other vegetable crops are pechay, mustard, eggplants, tomato, upo, squash, and patola. These are planted mostly in home gardens, in backyards, or in small open areas. The supply of leafy and fruit vegetables of the province is adequate.

Fruit trees.—Fruit trees constitute one of the principal crops of the province. The climate of the province is ideal for the growing of this crop. Besides being less visited by strong winds, it has a well distributed rainfall throughout the year which accounts for the favorable growing of different varieties of fruit trees. The ten leading fruit trees of the province arranged in the order of hectarage are shown in table 6.

Banana is the most important fruit tree in the province. It grows in all the soil types mapped and is planted in backyards, slopes of the hills, and mountains, and in open lands. It grows well also from sea level to as high as 3,000 feet above sea level in Claveria. In 1949, the area planted to banana was 4,840 hectares and the value of the produce was ₱1,152,000. Balingasag, Salay, and Claveria are the leading towns producing banana in the province.

Mango ranks second to banana in area planted. The value of the produce, however, is third to banana, lanzon being second. In 1949, the total value of lanzones amounted to ₱150,000, while that of mango was ₱127,500. Initao is the leading town producing mango followed by Cagayan de Oro. Kinogitan leads all the towns of Misamis Oriental in the number of lanzon trees which is closely followed by Gingoog. Talisayan, Mambajao, and Claveria are the other lanzon-producing towns of the province.

TABLE 6.—*Area, production, and value of produce of the ten leading fruit trees of Misamis Oriental Province*[9]

Names of trees	Area in hectares	Production in kilos	Value in pesos
Banana	4,840	2,880,000	1,152,000
Mango	400	318,750	127,500
Lanzon	340	750,000	150,000
Jackfruit	250	1,225,000	98,000
Coffee	250	61,000	91,500
Cacao	220	30,200	60,400
Avocado	110	98,290	34,000
Orange	90	78,140	27,660
Pomelo	40	70,000	7,000
Papaya	30	142,000	28,400
TOTAL	6,570	5,653,380	1,776,860

[9] Facts and Figures of the Philippines. Bureau of the Census and Statistics. (1948-1949).

AGRICULTURAL PRACTICES

Agricultural practices in Misamis Oriental do not differ from those followed in the other provinces of the country. The farmer uses generally the native plow and harrow as the main implements of tillage and the carabao or cows as source of power. Lately, the use of tractors has been introduced, but in a limited extent and confined mostly to the flat uplands and moderately rolling areas of Claveria.

Fertilizers are not commonly used by the farmer. Recently, however, a growing interest in the use of fertilizers has been noticed among the farmers. Such interest, if continued and properly implemented is a healthy sign of a change for a better agriculture in the province. Better seed selection and clean culture are practiced. Thorough preparation of the land is followed. On the other hand, plowing on the moderately rolling

Fig. 15.—Nipa leaves are made into nipa shingles for houses and other establishments. This is one of the home industries of the province. The picture was taken in Baliñgasag.

areas is up and down the slopes resulting in accelerated erosion. So much so that a greater portion under seasonal crops has a slope ranging from 3 to 12 per cent. There is no program of soil conservation and soil wastage due to erosion is widespread. Improvement of the badly depleted areas is little attended to, if not entirely neglected.

Crop rotation is practiced in a very limited extent by few farmers. The majority of them plant different crops regardless of their succession. This is not a sound practice because the soil is easily exhausted of its fertility.

Green manuring and the addition of crop residues to the soil are entirely ignored. Organic matter aids in the retention of moisture and also supply plant nutrients. When legumes are used as green manure, the nitrogen content of the soil is also increased. Strip cropping, contour furrowing and cover cropping of the rolling regions are not practiced. On the other hand, kaingin system of agriculture is still prevalent on the slopes of hills and mountains. This kind of agriculture should be discouraged because it is destructive and enhances soil erosion.

LIVESTOCK AND LIVESTOCK PRODUCTS

Livestock in the province of Misamis Oriental is principally raised by the farmers themselves. The carabaos and cows are chiefly used as work animals in the farm. Some progressive farmers have more than one of these animals, some chickens, goats, hogs, ducks and horses. They are raised either for meat or for milk.

Before World War II, a wide area of the rolling uplands were utilized for grazing cattle. The war, however, especially during the Japanese occupation, adversely affected this industry.

TABLE 7.—*Kinds, number, and values of livestock and poultry in Misamis Oriental Province*[10]

Kind of livestock & poultry	Number	Value in pesos
Carabao	12,800	2,329,600
Cattle	6,770	886,870
Horse	2,630	247,220
Hog	57,940	2,143,780
Goat	3,880	27,160
Sheep	900	8,100
Chicken	177,860	284,580
Duck	1,350	2,030
Goose	340	1,390
Turkey	200	990
TOTAL	264,670	5,931,720

[10] Facts and Figures of the Philippines. Bureau of the Census and Statistics. (1948-1949).

Practically all the commercially raised cattle were lost and the industry has not as yet been rehabilitated. Up to the time of the survey there has been only one cattle ranch in the province. Even the number of work animals in the farms have not increased much in some parts of the province that farmers still cultivate fields by means of hoes while other farmers rent tractors to plow their farms. Table 7 gives the kinds, numbers, and values of livestock and poultry raised in the province.

Poultry raising is confined to backyards. Almost every home has few chickens raised in its yard. There are some poultry raisers who keep larger flocks, but such projects could not be considered as commercial in scale.

LAND USE CHANGES

In the 1939 census of the Philippines, the farms of Misamis Oriental were classified into the following classes: (1) cultivated land, 67,233.01 hectares; (2) idle land, 25,790.55 hectares; (3) pasture land, 8,974.97 hectares: (4) forest land 7,792.88 hectares; and (5) other land, 2,869.87 hectares. Cultivated land included land cultivated to seasonal crops and those lands planted to coconut, fruit trees and nut trees. Idle land meant land suitable for the growing of crops, coconut, and fruit trees but which was not used for the purpose; neither was it used for pasture. Pasture land was used exclusively for pasture, and forest land was the portion of the farm land which was occupied with forest. Other land meant land occupied by houses, buildings, improvements, and waste land.

Land use changes in the province were from pasture, idle, and forest lands into crop lands and other lands. While there is no available record to show the land use changes that have taken place since 1939, records, however, show that the cultivated land has increased in area from 67,233 hectares in 1939 to 75,460 hectares in 1948, thereby correspondingly decreasing the areas of the other classes of farm land. This increase may be due to: (1) the increase in the population of the province from 213,812 in 1939 to 269,671 in 1948; (2) World War II and the unfavorable effect it created on food supply; (3) forest have encouraged the people to settle in the interior. The increase in population necessitated a bigger farm area to accomodate the expansion of agricultural activities in the province for the production of more food. Consequently more of the pasture and idle lands have been settled and cultivated into crop lands.

Even some of the lower hills and rolling regions inland have been turned into crop lands. Land concession had been subdivided and turned over for agricultural purposes after the timber had been cut and abandoned by the lumber companies.

Farm Tenure

The 1939 census of the Philippines classified the farmers of the province into four classes, namely, owners, part owners, tenants, and managers.

Owners are farm operators who own all the land in which they work. Part owners are farm operators who own part and rent or lease other parts of the land which they work. Tenants are farm operators who rent or lease from others all the land which they work, and managers are farm operators who supervise the working of the farm for landowners, receiving wages or salaries or part of the crops for their services.

The tenants are further classified into three, as follows: (a) Share tenants — farm operators who rent the land they work and pay as rent a share of the crop or crops grown; (b) Cash tenants are farm operators who rent the land they work and pay as rent a specified amount of money or a definite quantity of the crop or crops grown; (c) Share-cash tenants are farm operators who rent all the land they work and pay as rent a share of the crops in addition to a specified amount of money.

There is a total of 22,521 farms in Misamis Oriental with an area of 112,661.28 hectares. Of these farms, 71.56 per cent or 80,622.34 hectares are operated by owners; 7.61 per cent or 8,572.14 hectares are operated by part owners; 4.45 per cent or 4,997.04 hectares are operated by managers; and 21.44 per cent or 18,469.76 hectares operated by tenants, 16.12 per cent or 18,169.95 hectares of which are operated by share tenants, 0.17 per cent or 197.72 hectares operated by share-cash tenants, and 0.09 per cent or 102.09 hectares operated by cash tenants.

The farm land of the province is well distributed among the people. Only a small number are tenants. The average size of farm landholding is 5 hectares per farmer. This accounts for the absence of any serious agrarian problem between landlords and tenants in the province.

Farm Investment

It is difficult to give an idea regarding the amount of investment on the farms of Misamis Oriental. The farmers have no inventory of their own expenses and income. The farm equipment and the work animals are considered as investment in the farms in this report. The census of 1939 gives the investment on farm equipment and work animals as follows:

Kind of equipment	Number of equipment	Value (Pesos)
1. Plows	8,702)	
2. Harrows	2,912)	
3. Carts	550)	559,076
4. Sleds	2,973)	
5. Work animals	14,337)	

TYPES OF FARMS

Misamis Oriental has diversified agriculture. The census of the Philippines in 1939 gives the number of farms in the province classified according to types shown in table 8. They are described as follows:

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

2. Corn farms are farms on which the area planted to corn was equal to 50 percent or more of the area cultivated.

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

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

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

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

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

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

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

10. Other farms are farms which could not be classified under any of the above nine groups.

TABLE 8.—*Number of farms by type in Misamis Oriental*[11]

Type of farm	Number of farms	Per cent
Palay	1,355	6.02
Corn	6,006	26.67
Abaca	746	3.39
Sugar cane	8	0.03
Coconut	12,255	54.41
Fruit	97	0.44
Tobacco	12	0.05
Vegetable	351	1.56
Livestock	27	0.12
All others	1,646	7.31
Total	22,521	100.00

[11] Census of the Philippines, 1939. Agriculture. Province of Misamis Oriental. Bul. 33-A.

V. SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of (a) the determination of the morphological characteristics of soils, (b) the grouping and classifying of soils into units according to their characteristics, (c) their delineation on maps, and (d) the description of their characteristics in relation to agriculture and other activities of man.

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

On the basis of both the external and internal characterstics, 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 principal mapping units are in such intimate or mixed pattern that they cannot be clearly shown on a small-scale soil map, they are mapped or grouped into (4) a complex. Areas of land that have no true soil, such as river beds, coastal beaches, and bare rocky mountains, are grouped into (5) miscellaneous land types. Soils of areas that are inaccessible, like mountains and great forest regions, which are of no agricultural value for the present, are classified as (6) undifferentiated soils.

A series is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile, except for the texture of the surface soil, and developed from a particular type of parent material. It comprises soils having essentially the same general color, structure, consistency, range of relief, natural drainage condition, and other internal and external characteristics. In the establishment of a series, a geographic name is selected, taken usually from the locality where the soil was first identified. For example, the Mambajao series was first studied and classified in Mambajao, Misamis Oriental.

A soil series includes one or more soil types defined according to the texture of the surface soil. The class name, such as sand, loamy sand, sandy loam, silt loam, silty clay loam, clay-loam or clay, is added to the series name to give the the complete name of the soil type. For example, Mambajao clay is a soil type of Mambajao series. The soil type is the principal unit of mapping. Because of its specific characteristics, it is usually the unit to which agronomic data are definitely related.

The phase of a soil type is a variation within the type, which may be of special practical significance, differing from the soil type only in some minor features, generally external. Differences in relief, stoniness, and extent or degree of erosion are shown as phases. A minor difference in relief may cause a change in the necessary agricultural operation or a change in the kind of machinery to be used. The phase of a type with a slight degree of accelerated erosion may present different fertilizer requirements and other cultural management practices from the normal soil type. The phase or phases of a type due mainly to degree of erosion, degree of slope, and the amount of gravel and stones on the surface soils, are delineated on the map.

A soil complex is a soil association composed of such intimate mixture of series, types, or phases that cannot be indicated separately in a small-scale map. This is mapped as a unit and is called soil complex. If in an area there are several series, types or phases that are intimately mixed such as Mambajao, Camiguin, Jasaan, and others that are mixed together, the complex is named after the dominant member or members, such as Mambajao-Camiguin complex or Jasaan complex.

Surface soil and subsoil samples for chemical and physical analyses are collected representing each soil type or phase, the number of samples 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 soils men, maps the area and delineates on the map the various soil types, phases, complex, and miscellaneous land types. All local and cultural features found in the area are indicated on the soil map. These are trails, roads, railroads, bridges, telephones and telegraph lines; barrios, towns, and cities; irrigation canals, rivers and lakes; prominent mountains, etc.

VI. SOILS OF MISAMIS ORIENTAL

The soils of Misamis Oriental are predominantly clay. Other textures range from sand and loam to clay loam. They exhibit all shades of color from light gray, yellowish gray, brownish gray, reddish brown, red and black, but the reddish color is predominant. The lighter and reddish colors are mostly in upland and rolling to hilly regions while the brownish and other colors are in the coastal plains. Most of the soils are low in organic matter content. The consistency of both the surface soil and subsoils varies from loose and friable to moderately compact, sticky and plastic. These differences in consistency make the internal drainage variable. The surface drainage is influenced by the relief of the land.

About 84 per cent of the soils have sloping, rolling, hilly, or mountainous relief, 24 per cent of which is rough mountain or under thick forest that for the present has no immediate agricultural value. Large areas require extensive soil conservation practices, like terracing, strip cropping, contour cultivation, etc., if used for the growing of farm crops to minimize or reduce the losses of surface soil from run-off. Some areas should not have been brought under cultivation. As a result, soil erosion is very noticeable and truncation of soil profile is much in evidence. Gullies are plentiful. Some areas have been abandoned and have became cogonal.

The soils of the plains are considered the best agricultural soils of the province and can be farmed with ease. They are adapted to various farm crops. Occurring on a relief with a highest slope of about 3 per cent, they can be cultivated continuously for seasonal crops throughout the year with the least problem on soil erosion. With the use of such farm practices as application of commercial fertilizer and organic matter, green manuring, crop rotation, and proper tillage, they will give moderate to high yields.

Three general groups of soil on the basis of topographic position are found in Misamis Oriental, namely, (1) miscellaneous land types, (2) soils of the plains, valley, and undulating areas, and (3) soils of the hills, high uplands, and mountains. The soils in each group are in turn classified into soil types, based on the genetic and morphological characteristics of the profile. The soil types were mapped. Their descriptions and agricultural importance are discussed in the following pages. The areas, percentage, and the principal crops grown on each soil type are shown in table 9. The accompanying map shows their distribution and relative extent.

The soil types under each group are as follows:

1. Miscellaneous land types.
   a. Hydrosol (1)[a]
   b. Beach sand (118)
2. Soils of the plains, valleys, and undulating areas.
   a. San Manuel loam (190)
   b. Umingan loam (322)
   c. Umingan clay loam (168)
   d. Bantog clay (228)
   e. Matina clay (206)
   f. Mambajao clay (315)

[a] Number in parenthesis after each soil type is the type number.

3. Soils of the rolling areas, high uplands, hills, and mountains.
   a. Jasaan clay (317)
   b. Jasaan clay loam (318)

TABLE 9.—*Area, and principal crops on each soil type in Misamis Oriental*

Soil type No.	Soil type	Area in hectares	Percent	Principal crops grown
1	Hydrosol	2,114.82	0.54	Nipa, mangroves and for fishponds.
118	Beach Sand	3,992.80	1.02	The narrow strips along the coast has no agricultural value. Inland is planted to coconut; bananas and some fruit trees.
190	San Manuel Loam	13,462.75	3.44	Lowland rice, coconut, corn, camote, tobacco, bananas, vegetables, and fruit trees.
322	Umingan loam	5,577.10	1.42	Lowland rice, corn, coconut, tobacco, peanut, camote, fruit trees and bananas.
168	Umingan clay loam	2,502.47	0.64	Lowland rice, coconut, corn, bananas, and fruit trees.
228	Bantog clay	5,045.02	1.29	Lowland rice, coconut, corn, bananas, and abaca.
203	Matina clay	4,708.93	1.20	Lowland rice, coconut, corn, bananas, fruit trees, tobacco, and cogonal.
315	Mambajao clay	23,876.90	6.10	Lowland rice, corn, peanut, coconut, abaca, root crops, and bananas.
317	Jasaan clay	34,967.24	8.94	Abaca, sugar cane, upland rice, corn, tobacco, coconut, cabbage, pechay, peanuts, onion, fruit trees, and vegetables.
318	Jasaan clay loam	18,815.89	4.80	Abaca, upland rice, coconut, corn, fruit trees, bananas, root crops, cogonal and secondary forest.
319	Jasaan clay, stony phase	18,863.91	4.82	Coconut, bananas, ipil-ipil, fruit trees, cogonal and secondary forest.
321	Jasaan-Bolinao complex	4,592.95	1.17	Coconut, fruit trees, bananas, upland rice, corn, and root crops.
316	Lourdes clay loam	35,227.27	8.99	Coconut, upland rice, corn, bananas, camote, sugar cane, tobacco, cogonal, secondary forest.
320	Camiguin clay	67,101.86	17.13	Coconut, abaca, fruit trees, bananas, cogonal and secondary forest.
153	Bolinao clay	23,952.93	6.12	Coconut, bananas, fruit trees, upland rice, tobacco, ipil-ipil, corn, and cogonal.
182	Faraon clay	5,265.07	1.34	Coconut, bananas, fruit trees, upland rice, corn, cogonal and ipil-ipil.
126	Alimodian clay loam	9,729.99	2.48	Coconut upland rice, corn, bananas, fruit trees, cogonal and secondary forest.
45	Mountain soils undifferentiated	111,888.09	28.56	Primary forest, mossy forest and secondary forest.

c. Jasaan clay, stony phase (319)
d. Jasaan-Bolinao complex (321)
e. Lourdes clay loam (316)
f. Camiguin clay (320)
g. Bolinao clay (153)
h. Faraon clay (132)
i. Alimodian clay loam (126)
j. Mountain soil undifferentiated (45)

1. *Mechanical Analysis*

The mechanical analysis of the surface soils of the various soil types was made to check up the field classification which was done by the "feel method." The results are shown in table 10. Generally, the field classification agrees with the results of the mechanical analysis. There are cases, however, where the field classification is doubtful. Some of the soils exhibit the loam texture in the field. They are friable, mellow, and easy to cultivate but the clay content is high. Under these conditions, the field classification is maintained except when the clay content is so high that the textural grade is made to conform with that obtained by the mechanical analysis. The hydrometer method of mechanical analysis by Bouyoucos (7) was used.

TABLE 10.—*Average mechanical analysis of Misamis Oriental soils*

Type number		Sand (%)	Slit (%)	Clay (%)	Colloid (%)
190	San Manuel loam	48.0	40.8	15.6	25.6
322	Umingan loam	32.4	44.4	28.2	41.2
168	Umingan clay loam	32.8	32.2	41.0	52.2
228	Bantog clay	8.4	28.4	69.2	79.6
206	Matina clay	4.4	39.4	67.0	73.2
315	Mambajao clay	18.4	24.6	63.2	73.2
317	Jasaan clay	14.8	31.0	60.2	70.2
318	Jasaan clay loam	30.8	30.0	39.2	53.2
126	Alimodian clay loam	37.8	35.6	29.6	39.0
316	Lourdes clay loam	44.4	22.4	37.2	41.2
153	Bolinao clay	13.0	39.2	56.2	75.0
320	Camiguin clay	15.0	29.6	59.4	70.6
132	Faraon clay	12.0	47.8	48.2	60.6
321	Jasaan-Bolinao complex	32.4	23.6	51.0	63.2

2. *Miscellaneous Land Types*

All lands which possess little or no definite soil are classified under the group of miscellaneous land types.

Hydrosol (1).—A total of 2,114.82 hectares or 0.54 per cent of the total area of the province is mapped as hydrosol. This soil is usually found near the mouth of the rivers and in some protected bays. It is under water most of the time.

This soil has no agricultural value. It is, however, suited and adapted to the growing of nipa palms and some species of mangroves. It is also used as fishponds for the culture of "bañgus". The leaves of the nipa palms are made into nipa shingles (Fig. 15) for houses and buildings, while the mangroves are good sources of firewood. The areas nearby, which are not under water all the time are converted into salt beds for the extraction of salts.

Beach sand (118).—The beach sand is the narrow strip of sand along the seashore. This soil has no developed profile. A total of 3,992.80 hectares is mapped. Little further inland is planted to coconut, bananas, and some fruit trees. Coconut grows well in this soil.

B. *The Soils of the Plains, Valleys, and Undulating areas*

The soils under this group are the alluvial soils of the province. They comprise the coastal plains, the valleys in the interior, and the gently undulating areas of the lower uplands. The series are Umingan, San Manuel, Bantog, Matina, and Mambajao. They are developed from materials of recent alluvial depositions and as such show variable characteristics. The surface soils are of moderate fertility and fairly deep. The acidity ranges from pH 5.50 for the Mambajao clay to pH 6.40 for the Bantog clay.

These soils are planted to various crops, the most important of which is coconut, occupying more than half of the area. This is due to the fact that coconut is the principal money crop of the province. Lowland rice is the second important crop planted. Other crops are corn, banana, tobacco, vegetables, root crops, abaca, and fruit trees, such as avocado, star apple, oranges, papaya, lanzones, durian, and others. This group of soils have an area of 55,173.17 hectares or 14.09 per cent of the total area of the province. Mambajao clay is the largest soil type among the soil types in the group and coconut is the principal crop grown.

SAN MANUEL SERIES

This soil series was first identified and mapped in Tarlac Province. It is alluvial and considered one of the best soils devoted to lowland rice in Tarlac and Pangasinan Provinces. In Misamis Oriental, this soil is developed from materials washed from soils in the surrounding uplands and deposited by the streams as they flow to the sea. Coconut is the permanent and principal crop, while lowland rice is the important annual crop. San Manuel loam is the only soil type mapped under this series.

San Manuel loam (190).—This soil occupies a total of 13,462.75 hectares or 3.44 per cent of the total area of the province. It is found along the banks of the Ipona, Cagayan, and Tagoloan Rivers. The plain in Medina also belongs to this soil type. It is nearly level to slightly sloping with the highest slope of about 2 per cent. The surface drainage as well as the internal drainage is moderately good. The coconut area in Ipona has the following profile characteristics.

Depth of the soil cm.	*Characteristics*
0- 30 —	Surface soil, brown to pale brown loam to silt loam, moderately loose, friable and fine granular structure. It is easy to cultivate and contains adequate amount of organic matter. In some places the surface soil is grayish brown and in others, especially when the areas are devoted to lowland rice, the surface soil has plenty of brick red streaks. There is no stone or gravel and affords deep root penetration. It has a clear and smooth boundary with the subsoil.
30- 60 —	Upper subsoil, brown to pale brown silt loam, moderately fine granular, loose and friable.
60-100 —	Lower subsoil, brown to ash brown silt loam to fine sandy loam, loose and friable. Massive structure, clear and smooth boundary wtih the substratum.
100-150 —	Substratum, fine and grading to sand, yellowish brown loose and structureless.

San Manuel loam is practically cleared and cultivated, with about 80 per cent planted to coconut. The rest is devoted to lowland rice and occasionally planted to corn, tobacco, and vegetables. The average production of nuts per tree per year is 37. Rice yields 40 to 55 cavans of palay a hectare depending upon the availability of water supply and the variety of rice planted. Corn gives a yield of 8 cavans a hectare. This soil has never been fertilized since it has been first brought into cultivation.

San Manuel loam is of average fertility. Chemical analysis [a/] of the soil samples collected for this soil indicates deficiency in ammonia. Under this circumstance, the addition to the soil of a liberal amount of ammonium sulfate fertilizer is important to supply the deficiency in ammonia and increase the

a/ Table for the chemical constituent of the soil types and the interpretation of the chemical tests are found elsewhere in this report. Prepared by the Division of Soil Laboratories, BSC., DANR.

yields of the crops. The soil has a pH of 5.8 which is medium acid in reaction.

UMINGAN SERIES

The soils of the Umingan series occur in close association with the San Manuel soil. They resemble in color but differ mainly in that the Umingan series has a layer of stones and gravels accumulation it its profile, a characteristic which is absent in the San Manuel series. In some places there are two layers of these accumulations found in the profile which are separated by a layer of sand. The first layer occurs a few centimeters to about a meter below the surface, and the second layer is about fifty centimeters to one meter or more below the first layer of stone accumulation. This is a distinct characteristic of this soil series.

In most places the surface soil is brown, grayish brown to light brown and the subsoil is light brown to pale brown sandy loam, clay loam to silt loam, loose and friable. These soils are developed from materials deposited by the flowing streams from the high uplands. They occur on a level to slightly undulating topography and usually along the river banks, or plains formed between bodies of rivers. Surface and internal drainage are generally adequate. At places, however, there are patches of swaled areas which are poorly drained both externally and internally. Umingan loam and Umingan clay loam are the soil types mapped.

Umingan loam (322).—This soil can be farmed with less effort, because it occurs on a level to slightly undulating areas. A total of 5,577.10 hectares or 1.42 per cent of the total area of the province is mapped. The largest areas are in the Balingasag-Lagonglong plain and the Alubijid plain. For agricultural purposes, this soil is suited to the cultivation of various farm crops, and responds well to good management. It is easily tilled. The only hazard to agriculture is the over flooding especially those areas along the river banks. It has the following profile characteristics taken from a rice field in Lagonglong.

Depth of the soil cm.	*Characteristics*
0- 35 —	Surface soil, brown to grayish brown, loose, granular loam to silt loam with fair amount of organic matter. Affords good root penetration. In some places, stones are found in the surface which, however, do not interfere in cultivation. Soil boundary to the subsoil is clear and smooth.

35- 65	— Subsoil, light brown to brown, loose, friable and fine granular silt loam. Poor in organic matter, abrupt and smooth boundary with the lower horizon.
65-100	— Light brown to ash brown, loose and friable. Fine granular sand.
100- 30	— Layer of gravels, pebbles, and stones accumulation. This layer varies to a depth from few centimeters, to about one meter or more from the surface soil. This accumulation is the main characteristics of this soil which distinguishes it from the other soils.
130-below	— Substratum, brown, light brown to ash brown sand, loose and structureless.

The Umingan loam is one of the best agricultural soils of the province. It is especially important because of its level to slightly undulating relief, and its wide crop adaptability. The areas mapped are cultivated and about 70 per cent of which is permanently planted to coconut. The rest is devoted to seasonal crops. Rice is the main crop, and corn, camote, and vegetables are the secondary crops. Coconut yields 30 to 40 nuts per tree per year and rice yields 35 to 45 cavans of palay per hectare.

This soil is low in readily available nitrates and potassium. When the land is fertilized with ammonium sulfate and potassic fertilizers the nitrate and potassium content of the soil would be brought to normal for the growth of the crops, thus would improve the production in this soil. The soil reaction is medium acid, the pH value being 6.10.

Some coconut fields are cogonal and the growth of the trees is quite poor. With this condition it is advisable to cover crop the fields with Centrosoma or Calopogonium. These cover crops help eradicate the cogon. Besides, they fix atmospheric nitrogen in the soil and improve it physically to the desired condition for the better growth of the coconut trees.

Umingan clay loam (168).—Umingan clay loam is the other soil type mapped under the Umingan series. It differs mainly from the Umingan loam in that it has a clay loam surface soil to a depth of 25 to 30 centimeters. The relief is level to slightly undulating. The greatest slope do not exceed 4 per cent. The external and the internal drainage are good.

The areas are small and scattered, and in close association with the Umingan loam and San Manuel loam. A total of 2,502.47 hectares is mapped. About 50 per cent is cultivated and the rest is in cogonal and secondary forest. The forested and cogonal areas, when cleared, can be planted to coconut, fruit trees, rice, or other seasonal crops. Almost half of the tilled area is permanently planted to coconut and the other half is used principally for lowland rice and corn. Root crops, vegetables, and fruit trees are also planted. Coconut has a fair production of nuts per tree per year. Rice yields 35 to 40 cavans a hectare; corn, 5 to 10 cavans.

The chemical tests of Umingan clay loam show a medium acid reaction, a pH of 5.8. It contains low readily available phosphorus, hence the addition of phosphatic fertilizer like Ammo-phos is essential to increase the phosphorus content of the soil and the yields of the crops.

BANTOG SERIES

The soil of the Bantog series occurs on level areas and is developed from materials washed from the weathered products of basalts, andesites, and shales of the upland. It has a brown to dark brown clay surface soil and brown to light grayish brown clay subsoil. The external drainage is adequate but the internal drainage tends to be slow. Bantog clay is the only soil type mapped.

Bantog clay (214).—This soil is found scattered in small areas in the province. The largest areas are the plain in Gingoog proper and the coastal plain along the national road from kilometer 143 to kilometer 160 going to Agusan Province. The other areas are located in the eastern part of the Cagayan de Oro plain, and parts of the plains in Opol and Alubijid. Occuring on a nearly flat surface with a slight slope in a direction of stream flow, this soil has a fairly adequate external drainage. The internal drainage, however, tends to be slow due to the textural character of the soil. The following is a profile characteristics of this soil taken from the rice field in Opol.

Depth of the soil cm.	*Characteristics*
0- 35	— Surface soil, brown to dark brown clay, compact, sticky, plastic, and good medium granular structure. In the rice paddies, it is quite soft and has plenty of reddish streaks. In the uncultivated areas, it is hard and cracks to as deep as one foot when dry. It has a fair organic matter content and affords deep root penetration. It has a diffused and smooth boundary with the subsoil.
35- 90	— Subsoil, brown light brown to grayish brown, moderately medium columnar to granular structure. It is hard and compact clay especially when dry, sticky and plastic when wet.
90-150	— Substratum, grayish brown clay with dark brown mottlings, moderately medium granular and slightly crumbly when dry, plastic and sticky when wet. It is slightly compact.

Bantog clay is suited to the growing of various farm crops. Practically, all the areas are cultivated, but about one half of the total area is planted permanently to coconut. The rest is devoted to lowland rice as the main crop; corn, camote, tobacco, vegetables, and some root crops are the secondary crops. Coconut gives a fair yield of nut per tree per year. The production of rice and corn is of the average.

This soil has a slightly acid reaction, the pH value being 6.4. It is deficient in nitrates but contains normal readily available ammonia, phosphorous, and potassium. Ammonium sulfate fertilizer when added would supply the needed nitrogen for the growth of the plants and would improve the yields of the crops.

MATINA SERIES

The soil of the Matina series occurs on level to nearly level topography and has been developed from recent alluvium washed down from hilly areas of shale, calcareous shale and limestone formation. It has a very dark brownish gray to black clay loam to clay, coarse granular surface soil, and a dark grayish brown plastic clay with a medium columnar structure subsoil. Below 90 to 100 centimeters from the surface is a brown sandy clay loam slightly compact and with a yellowish mottling. This soil is one of the young soils that has not had enough time to develop as manifested by its profile. Matina clay is the only soil type mapped.

Matina clay (206).—Areas of this soil occupy the plain in Lourdes, the coastal plain in Manticao, the rice field between the Cagayan and Ipona Rivers along the highway, and the plain from Kilometer 7 to barrio Opol, Cagayan de Oro, along the highway. The largest areas are found in Manticao and in Cagayan. The total area mapped is 4,708.93 hectares.

The relief is level to nearly level. The drainage, both surface and internal, is slow. The surface soil and subsoil are dominantly black. Their depths are shown in the profile description. Few gravels of calcareous limestone are found in the surface in some places and in other places gravels are also found in the upper subsoil. Following is a generalized profile description of this type taken from a rice field in Lourdes. Figure 16 is the profile picture.

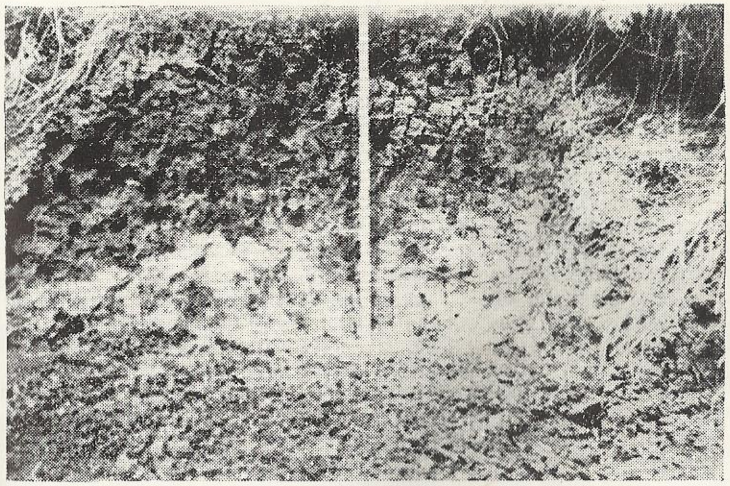

Fig. 16.—Profile picture of Matina clay taken in the rice field of Lourdes. This is a deep soil and the color is dark to black.

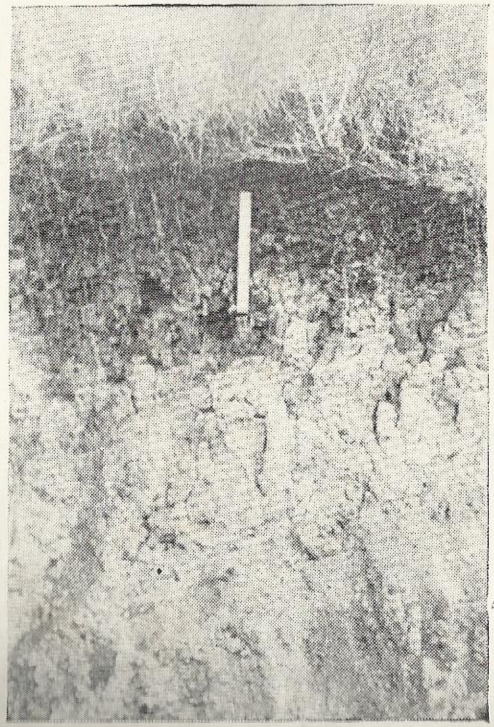

Fig. 17.—Profile picture of Mambajao clay taken from Mambajao. This soil is deep and has a brown color.

Depth of the soil cm.	Characteristics
0- 30 —	Surface soil, very dark brownish gray to black clay loam to clay. Coarse granular and brittle when dry, but plastic when moist. Slightly compact, affords deep root penetration and fair in organic matter content. Gradual wavy boundary into the lower layer.
30- 45 —	Subsoil, gray to dark grayish brown plastic clay with medium columnar structure. Root penetration reaches this horizon. Clear and smooth boundary.
45- 90 —	Lower subsoil, soft, granular brown clay to clay loam. Clear and smooth boundary into the substratum.
90-150 —	Substratum, brown sandy clay loam, slightly compact, medium columnar structure.

This soil is easy to till and responsive to good management. It is not susceptible to erosion due to its nearly level relief and when properly managed may give high yields of all locally grown crops. About 80 per cent of the area is under cultivation and the rest is shrubby and open land. The cultivated area is almost equally planted to coconut and to lowland rice. It is adapted to both crops and also other farm crops. Coconut gives a good yield of nut per tree per year. Rice yields 35 to 40 cavans a hectare with the rice fields unfertilized. Other crops grown are corn, tobacco, root crops, vegetables, fruit trees, and banana.

Matina clay is slightly acid in reaction. The pH value of the soil is 6.4. Application of commercial fertilizer in this soil is not practiced. Chemical test shows that the soil contains fair amount of readily available essential elements for the plants. Under good soil management and proper farming practices, this soil will give high yield for the crops planted.

MAMBAJAO SERIES

Mambajao series is a new soil series identified in the municipality of Mambajao, Camiguin Island. The soil of this series has been developed from recent alluvium washed down from hilly areas of andesite and volcanic formation. The relief is level to sloping and moderately undulating with the greatest slope of about 6 per cent. The elevation is from sea level to about 500 feet above sea level. The sloping area is well drained but the level portion has slow internal and external drainage. It is characterized by a brown to light brown and strong brown moderately compact clay surface soil and a light brown to reddish brown moderately compact clay subsoil. Mambajao clay is the only soil type mapped.

Mambajao clay (315).—Agriculturally, this is one of the most important soils of Misamis Oriental Province. It occupies an area of approximately 23,876.90 hectares or 6.10 per cent of the total area of the province. Areas of this soil are scattered in Camiguin Island and in the eastern part of the province, with the largest areas between the municipalities of Gingoog and Medina and also between Talisayan and Kinoguitan. Quite extensive areas are also found in Mambajao and Catarman. The following profile (Fig. 17) gives the internal characteristics of this soil. It is taken from a coconut field in Mambajao.

Depth of the soil cm.	*Characteristics*
0- 30 —	Surface soil, brown, light brown to strong brown moderately compact clay. Soft and friable when moist, sticky and plastic when wet, and hard and compact when dry. Columnar to fine granular structure fair, in organic matter content and affords good root penetration. Boundary with the subsoil is wavy and diffused.
30- 65 —	Subsoil, brown, light brown to reddish brown and moderately compact clay. Moderately sticky and plastic when wet, soft and friable when moist, and brittle when dry. Columnar structure with clear and smooth boundary with the lower horizon.
65- 95 —	Gravelly clay with few stones, brown to reddish brown.
95-150 —	Substratum, sandy clay, brown to yellowish brown with grayish black mottling and few sandstone gravels. Compact and massive structure.

Sheet erosion is noticeable in the sloping area. It is quite active particularly in areas under clean culture. The total area devoted to this kind of farming, however, is small and is mostly in upland rice, peanut, and corn.

Mambajao clay is suited to all locally grown crops, being under the second type of rainfall. About 40 per cent of the total area is cultivated, 70 per cent of which is mostly in permanent coconut field giving a yield of from 35 to 40 nuts per tree per year. The 30 per cent is planted to abaca as the main crop. Other crops are fruit trees, rice, peanuts, corn, gabi, cassava, and banana. Abaca yields 20 to 30 bales of 63 kilos a bale per hectare in Mambajao before the Hibok-Hibok volcano erupted in 1948.

The uncultivated area is in secondary forest and grass lands, all of which when cleared can be used successfully for the growing of agricultural crops. In Minsapinet, Gingoog is a wide level to gently rolling area with portions planted to rice and other seasonal crops cultivated with the use of hoes. This is because work animals in this place are scarce and for this reason it is not uncommon that rice and other seasonal crops are cultivated like the kaingin method.

The chemical tests of Mambajao clay show a pH value of 5.5 which is medium acid. It is low in readily available nitrates and phosphorus. With good management and with the application of sufficient amount of ammonium phosphate fertilizer, crop yields may be increased.

4. *The Soils of the Hills, High Uplands, and Mountains*

The soils occupying the rolling areas, hills, plateau and mountains are placed under this group of soils. In this group are six soil series, one soil complex, and one land type. These are Jasaan, Alimodian, Lourdes, Bolinao, Faraon, and Camiguin series; Jasaan-Bolinao complex; and Mountain soils undifferentiated. The total area is 330,400.20 hectares or 84.35 per cent of the total area of the province.

These soils had developed from the weathering of various rocks, such as basalt, andesite, undifferentiated metamorphic rocks, shales, coralline limestone, and sandstone. The Jasaan, and Camiguin series had developed from the residual material of conglomerate, basalt, and andesite; Faraon and Bolinao from coralline limestone and the Alimodian and Lourdes series from shale and sandstone. Jasaan series has its parent materials weathered too deep that the resulting soil has a thickness of 2 meters or more.

Occurring on hilly and mountainous areas, these soils have a rugged surface. There are many sharp angular hills cut by streams in deep gorges. Numerous gullies (Fig. 18), narrow ravines, and canyons are also present in this group of soils indicating how seriously erosion have taken place. Surface drainage is good to excessive and the internal drainage is fairly adequate. The hills and rolling areas along the coast are extensively planted to coconut. The flat and rolling areas inland are either used for pasture or cultivated for the growing of agricultural crops, or when not in used, are cogonal, open land and secondary forest. The higher hills and the mountains including portion of the rolling areas bordering Bukidnon and Agusan are thickly forested. The cultivated areas are planted to coconut, abaca, fruit trees, upland rice, corn, root crops, and vegetables. The pH value ranges from 5.15 of the Jasaan clay to pH 6.75 of the Faraon clay.

JASAAN SERIES

Jasaan series is a new soil series identified in Jasaan. The soils of this series are primary soils developed in place from the weathered volcanic rocks, such as basalt and andesite. The relief is flat upland, rolling, hilly, and mountainous. The external drainage is good to excessive and the internal drainage is fair. Erosion especially in the rolling and steep regions is serious resulting in the truncation of the profile. In many places the parent rocks are exposed to the surface. The surface soil is brown to light brown clay loam to clay and the subsoil is light brown to reddish brown. Where erosion has taken place the surface soil is light brown. Normally the parent materials of these soils had been weathered too deep that the resulting soils have a thickness of 2 or more meters. Jasaan clay, and its stony phase, Jasaan clay loam, and Jasaan-Bolinao complex were mapped.

Jasaan clay (317).—This type covers an area of 34,967.24 hectares or equivalent to 8.94 per cent of the total area of the province. The largest area mapped is in the environs of Claveria, Jasaan, and Balingasag. Other areas mapped are located in Gingoog, along the Gingoog-Claveria proposed road, and in Cagayan de Oro, along the Bugo-Malaybalay road. The relief is flat upland, rolling, and hilly to mountainous. The external drainage is fairly adequate. The cultivated area in Hinaplanan has the following profile characteristics. Figure 19 shows the profile picture.

Depth of the soil cm.	*Characteristics*
0- 35 —	Surface soil, moderately compact clay loam to clay, brown to light brown, slightly friable, and soft when moist, sticky and plastic when wet, but hard when dry. Has a fairly good amount of organic matter and affords deep root penetration. It has a columnar structure. In some places, stones and boulders are embedded in the profile. The boundary to the subsoil is clear and smooth.
35- 50 —	Upper subsoil, clay, light brown to reddish brown, moderately compact and columnar structure. Root penetrates down to this horizon. No gravel or stone in this horizon.
50-100 —	Lower subsoil, same as above except for the presence of gravel and stones in this horizon. Boundary to the substratum is diffused.
100-150 —	Substratum, clay loam, light brown to reddish brown, loose and very friable. Massive structure. This horizon has a thickness of one meter or more.

This soil can be successfully farmed. It is, however, important to practice soil conservation in farming this soil due

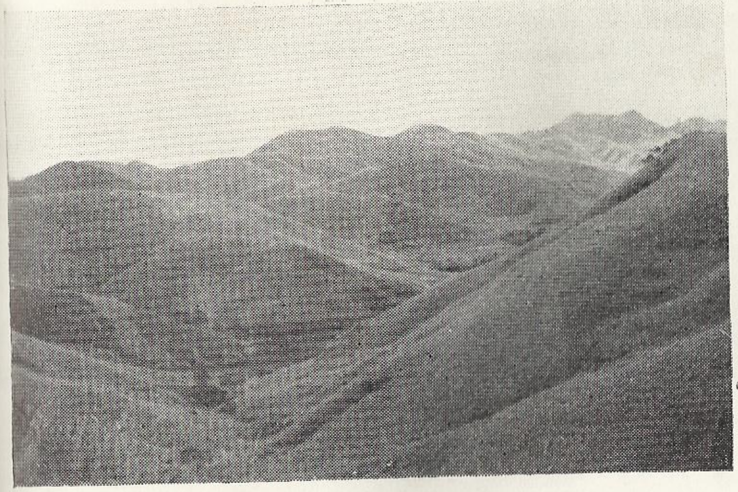

Fig. 18.—Portion of the rolling area of the province showing numerous gullies. The picture was taken in Lumbia.

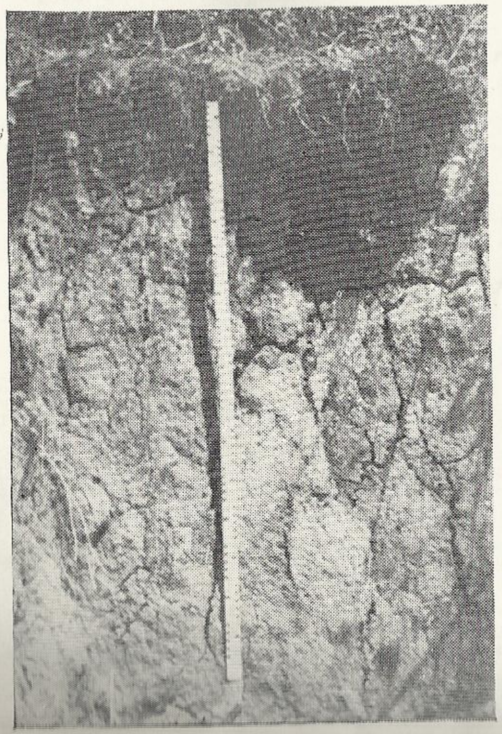

Fig. 19.—Profile picture of Jasaan clay. This is a deep soil and has a brown to reddish brown color. Taken from the upland rice field in Hinaplanan.

PLATE 9

to its rolling relief, otherwise, erosion will become excessive. In Hinaplanan, Claveria, besides using animal power to plow the farms the farmers employ five tractors. The method of plowing, however, is up-and-down the slope. This is destructive cultivation because it promotes in no little degree sheet erosion by allowing the concentration of run-off in furrows. Terracing, contour cultivation, strip cropping, and a long range crop rotation should be practiced especially on the more sloping areas. These practices help not only to check and protect the soil from further sheet erosion but they also improve the soil fertility and increase production.

About 30 per cent of this soil is under cultivation; the rest are in cogonal, and secondary and primary forest. Upland rice and abaca are the main crops. Corn, cabbage, native onion, pechay, root crops, vegetables, fruit trees, coconut, and banana are the secondary crops. Upland rice yields 50 to 65 cavans a hectare of unfertilized fields. This high production may be due to the favorable climatic condition occurring in the area and the fact that the land has been newly opened for cultivation.

Abaca yields 15 to 25 bales a hectare of about 63 kilos a bale. In the barrios of Rizal, Tamboboang, and Madaging of Claveria, abaca plants are growing luxuriantly that the production reaches as high as 35 piculs a hectare. The abaca plants are planted both in the level and rolling to hilly areas with an elevation of about 2,800 feet above sea level. These barrios of Claveria have the potentialities that can sustain the requirements of an expanded abaca industry. Given proper facilities, they may become one of the best abaca producing areas in Mindanao.

One of the important secondary crops planted in Jasaan clay is cabbage. In Luna, Claveria where the elevation is about 2,800 feet above sea level and the temperature is mild even during the day, cabbage is planted in truck gardens (See Fig. 14). The production per hectare ranges from 9,000 to 12,000 kilos and a cabbage head weighs 1.2 to 3.5 kilos. The cabbage fields are not fertilized.

Jasaan clay is low in readily available nitrates, phosphorus, and calcium. To correct these deficiencies one has to add a liberal amount of ammonium phosphate fertilizer and lime in order to bring the soil to a higher state of fertility. The pH value of the soil is 5.45 which is quite acidic.

Jasaan clay, stony phase (319).—The difference between Jasaan clay, stony phase and Jasaan clay is the presence of plenty of stones and boulders on the surface of the former, which makes cultivation impossible without their removal (Fig. 20). This soil occurs in the upland and rolling areas of Cagayan de Oro, and the rolling and hilly areas above the coastal plain from Cagayan de Oro to Jasaan. A total of 18,863.91 hectares of this was mapped. Practically the whole area is freely and excessively drained that sheet erosion is and has been active in this soil.

Spots and small areas are cultivated after diligently removing the boulders and stones. They are planted to upland rice, corn, vegetables, and some root crops. Some areas are planted to coconut and bananas without removing the stones. They are planted in between the boulders. The flat areas in Cagayan de Oro which are cogonal are used for pastures. The natural vegetation is cogon with scattered binayoyo trees and secondary forest. This soil is not suited to agriculture and should be left under cogon and forest. It could be used for pasture purposes to some extent.

Jasaan clay loam (318).—This soil occupies the southern part of Lumbia along the Cagayan River up to the border of Lanao Province. A total of 18,815.89 hectares or 4.80 per cent of the total area of the province was mapped. The relief is rolling, hilly, and mountainous. In many places, erosion has been severe forming plenty of gullies. The fields under clean culture have active sheet erosion.

Jasaan clay loam is similar to Jasaan clay. They differ largely in the texture of the surface soil in that while the former has a clay loam surface soil, the latter has clay. The surface soil with depth of from 30 to 35 centimeters is brown to light brown, moderately loose, soft and friable when moist and contain a fair amount of organic matter. Below the surface soil to the substratum, the characteristics are the same as those of the Jasaan clay.

Small and scattered areas of this soil are cultivated. The rest are cogonal and secondary forest. The rolling areas when cleared could be cultivated to agricultural crops or for pasture. When used for crops it is essential that farm management should require soil conservation practices, such as crop rotation with legumes, contour and strip cultivation and cropping, cover cropping, and terracing to protect the soil from further sheet erosion. Abaca, fruit trees, root crops, pineapple, corn, vegetables, banana, and upland rice are suited to this soil.

Jasaan clay loam needs phosphatic fertilizer and lime. Its available phosphorus is only 6 parts per million while that of calcium is 1,400 parts per million. These are low for the normal needs of the crops and therefore requires the application of sufficient amount of phosphatic fertilizer and lime. The soil has a pH value of 5.90.

Jasaan-Bolinao complex (321).—This soil complex is an association of the Jasaan and Bolinao soils that one or the other cannot be indicated separately in the map used. Therefore, the association is mapped as a unit and called complex. The dominant texture of the soil is clay. It occupies the hills east and west of Jasaan, and covers an area of 4,592.95 hectares.

Being hills with steep slopes, the external drainage is excessive and erosion has been serious. About 40 per cent of the area is planted to coconut and bananas. A small portion is planted to upland rice, corn, and root crops by the use of the kaingin system. The rest is in secondary forest. This soil should be left under permanent crops or in forest to prevent serious erosion.

LOURDES SERIES

Lourdes series is a new soil series identified in Lourdes, Misamis Oriental Province. The soil of this series is a primary soil developed from the weathering of undifferentiated metamorphic rocks and sedimentary rocks, such as sandstone and shales. It has a brown to dark brown moderately compact clay loam surface soil and a brown to light brown slightly compact sandy clay loam subsoil speckled with black and reddish color in the lower layer. The relief ranges from rolling to hilly and mountainous. Except the small valleys between the hills where the drainage is not adequate, the area has generally excessive external drainage. The native vegetation is cogon and forest. Lourdes clay loam was mapped.

Lourdes clay loam (316).—This soil lies in the environs of Lourdes, the western part of Lumbia, and in the south-western part of Cagayan de Oro. A total of 35,227.27 hectares or 8.99 per cent of the total area of the province was mapped and about 90 per cent of which is cogonal, secondary and primary forests. The rest is cultivated. Occurring generally on a rough terrain, the surface drainage is excessive and erosion has been serious. Numerous gullies, narrow ravines and canyons are found in this soil. In many parts of the area the surface soil is thin and in some other places the rock under has been exposed to the surface. This type has the following profile characteristics taken in a cogonal field in barrio Awang, Cagayan de Oro. The profile picture is shown in Figure 21.

Depth of the soil cm.	*Characteristics*
0- 25 —	Surface soil, brown to dark brown clay loam, moderately compact, sticky when sufficiently wet, slightly friable when moist, and hard when dry. Has tubular pores, fair in organic matter content and granular structure. In some places, gravels and stones are found in this horizon. The boundary into the subsoil is clear and smooth.
25- 45 —	Upper subsoil is brown to light brown sandy clay loam, slightly compact brittle and crumbly when dry and moderately friable when moist, granular structure. Iron concretions are found in some places in this horizon. The boundary is diffused.
45-100 —	Lower subsoil, ash brown to light brown clay, speckled with black and reddish color, friable when moist and brittle when dry. Massive structure and has a diffused boundary with the substratum.
100-150 —	Substratum, brown to ash gray brown clay loam to loam, speckled with reddish yellow color and presence of dark brown mottling. Massive structure.

There are areas of this soil which were previously under cultivation but were abandoned because the land could no longer give profitable income due to erosion. However, there are areas, such as the small valleys and the flat uplands which when properly managed, can be used economically for farming purposes.

Lourdes clay loam is more adapted to pasture and forest purposes than for agriculture. It has been badly depleted of its fertility due to erosion. In many cases, the surface soil has been removed leaving the barren subsoil. Consequently, agriculture is not economically productive. Farming this soil needs special conservation practices to reduce erosion damage, reclaim the soil and to build the soil to a higher state of fertility. Heavy application of ammonium phosphate fertilizer, addition of organic matter, crop rotation with legumes, green manuring, terracing, contour and strip cropping, and good tillage operation are very necessary and important farming practices in this soil to produce good yields. The soil has a pH value of 5.8

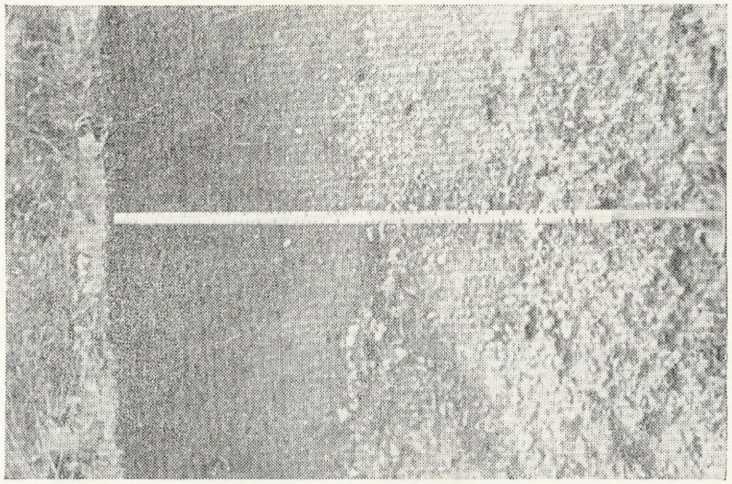

Fig. 21.—Profile picture of Bolinao clay. Below 80 centimeters from the surface is a weathering limestone rock, the parent material. Taken along the road to Initao.

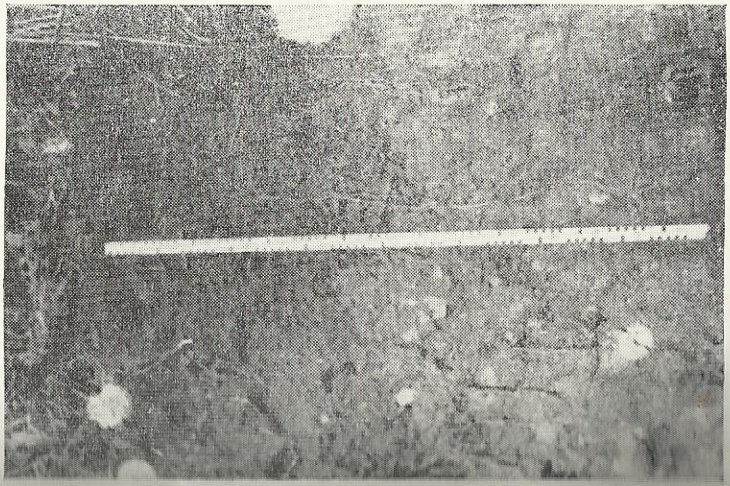

Fig. 20.—Profile picture of Lourdes clay loam. Taken from a cogonal field in the barrio of Awang, Cagayan de Oro City. Pasture land.

which is medium acid reaction. Upland rice, corn, sugar cane, tobacco, fruit trees, bananas, coconuts, root crops and vegetables are grown in this soil.

BOLINAO SERIES

The soil of the Bolinao series is light to dark reddish brown, moderately compact clay surface layer and a reddish brown heavier clay fine to coarse granular subsoil. This soil has developed from the weathered products of dark to reddish-colored coralline limestone. The topographic feature is nearly flat upland, undulating to rolling upland, and hilly. Surface run-off is slow to excessive and the internal drainage is fair. Bolinao clay was mapped.

Bolinao clay (153).—Areas of this soil occupy practically the whole municipality of Alubijid and El Salvador, and a bigger portion of the municipality of Initao. Small portions occur in Cagayan de Oro and Lumbia bordering Bukidnon Province. A total of 23,952.93 hectares was mapped It has the following profile characteristics. The profile picture is shown in Fig. 22.

Depth of the soil cm.	*Characteristics*
0- 35 —	Surface soil, brown to reddish brown clay, compact and hard when dry, plastic and sticky when wet, well developed structure, high moisture holding capacity. Roots penetrate easily and are abundant in this layer. Has limited amount of well-decomposed organic matter. Boundary with the subsoil is clear and smooth.
35- 55 —	Subsoil, strong brown to reddish brown clay, compact and hard when dry, highly sticky and plastic when wet, fine to coarse granular, and has a clear and smooth boundary with the lower horizon.
55- 80 —	Lower subsoil, differs only from the above horizon due to the presence of limestone gravels. Diffused boundary with the lower horizon.
80-120 —	Reddish brown weathered limestone rocks, soft, and granular with gravels. At some places this layer is as deep as 2 meters from the surface.
120-150 —	Reddish, porous and hard limestone rocks.

In some places the surface soil has abundance of angular and rounded limestone gravels. In the eroded condition limestone boulders and outcrops appear scattered on the surface interfering in the cultivation. Sheet erosion has been serious in this soil.

About 30 per cent of this soil is cultivated and 80 per cent of which permanently planted to coconut; the rest is planted to upland rice, corn, banana, some fruit trees, sugar cane, tobacco, and vegetables. The uncultivated areas are cogonal, secondary forest or covered with ipil-ipil.

Bolinao clay needs a heavy application of phosphatic fertilizer like ammo-phos. This is because chemical test found this soil to be containing only 3 parts per million of readily available phosphorus which is very much below the normal need of the plants. Farming practices like the addition of organic matter, green manuring, crop rotation with legumes, terracing, contour farming and good tillage operation are essential to make the soil produce high yield as well as to conserve it. The soil reaction is slightly acid, the pH value being 6.4.

FARAON SERIES

Like the Bolinao soil, the soil of the Faraon series is developed from the weathered products of coralline limestone, but the resulting soil is dark brown to black slightly compact clay in the surface layer and dark yellowish-gray clay subsoil. The limestone rock under is grayish to white in color, while that of the Bolinao series is reddish brown. The relief is undulating to rolling upland and hilly. External drainage is good to excssive and internal drainage is fair. Erosion in this soil has been active and serious. Faraon clay is the soil type mapped.

Faraon clay (132).—This soil occupies the western part of Initao and the rolling and hilly portion of Manticao along the coast to the border of Lanao Province on the west. It has a total area of 5,265.07 hectares. The profile characteristics of this soil taken from a coconut field in Manticao is described below.

Depth of the soil cm.	*Characteristics*
0- 30 —	Surface soil, dark brown to black clay, slightly compact, medium granular structure, soft and very strongly plastic when wet, slightly hard and brittle when dry. High moisture holding capacity. Abrupt and smooth boundary with the subsoil.
30- 45 —	Subsoil, dark yellowish-gray clay, strongly plastic when wet but hard when dry, and moderate fine granular structure. Mixed in this layer are partially weathered limestone rocks. The boundary with the lower horizon is clear and smooth.
45- 60 —	Yellowish-gray highly weathered limestone rocks, soft and weak-coarse granular.
60-150 —	Grayish to white porous limestone rocks, soft and easily broken.

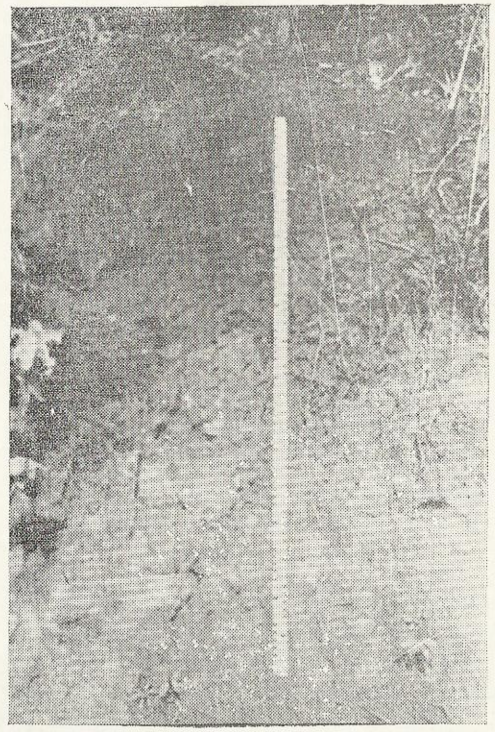

Fig. 22.—Profile picture of Camiguin clay. This soil type represents the largest soil in Misamis Oriental. The picture was taken along the road to Kinoguitan.

In some places angular and rounded limestone gravels are abundant in the surface soil. In the rolling and hilly areas the surface soil is thin and in other places the surface soil has been entirely removed exposing the dark yellowish-gray subsoil. This is due to erosion which has been active in this soil

About one half of this soil is cultivated and 80 per cent of which is permanently planted to coconut. The rest is devoted to upland rice, corn, banana, fruit trees, root crops, tobacco and vegetables. This soil is good for orchard, especially citrus, mangoes, banana, and other fruit trees. The limestone when properly prepared is good for liming sugar cane and rice fields. It is also good for road surfacing. The uncultivated areas are either cogonal, secondary forest or covered with ipil-ipil.

CAMIGUIN SERIES

Camiguin series is the other new soil series identified in Misamis Oriental. This soil was first found and mapped in Camiguin Island. This is closely associated with the Mambajao and Jasaan soils. It differs from the last two soils in that the Camiguin soil has big boulders of basalt and andesite as well as rock outcrops scattered in abundance in the surface soil. These are also embedded in the profile. These boulders and outcrops make cultivation with the use of plow and tractors impossible. The relief is rolling, hilly, and mountainous. The elevation is from 300 feet above sea level to 3,000 feet. Due to the relief, the surface run-off is good to excessive. The internal drainage, however, is fair. The native vegetation is cogon, few cultivated crops, and secondary and primary forests. Camiguin clay is the only soil type mapped.

Camiguin clay (320).—This soil had developed from the weathered products of volcanic sand, basalt, and andesite rocks. It is widely distributed in Camiguin Island and in the eastern part of the province. It is one of the extensive soils in the province covering a total area of 67,101.86 hectares. It has the following profile characteristics taken from a coconut field in Quinoguitan. Figure 23 shows the profile picture of this type.

Depth of the soil cm.	*Characteristics*
0- 25 —	Surface soil, dark brown, brown to light brown compact clay, hard when dry, sticky and moderately plastic when wet. Medium granular structure, fair root penetration, and has a

limited amount of well-decomposed organic matter. Clear and smooth boundary with the subsoil.

25- 55 — Upper subsoil, brown to light brown clay, compact and hard. Root penetration reach this horizon. Columnar structure and poor in organic matter.

70- 70 — Lower subsoil, light brown to reddish brown clay with few sandstone gravels. Columnar and diffused boundary.

70-100 — Strong brown to reddish brown clay loam to sandy loam with sand stone gravels and few stones. Massive structure and has a clear and smooth boundary with the lower horizon.

100-150 — Substratum, clay loam to sandy loam, light brown to reddish brown spotted with a mixture of brick red and dark brown weathered sandstone. Massive structure.

About 10 per cent of this soil is cultivated which is mostly located along the shore, and practically all this cultivated land is devoted permanently to coconut. Small area is planted to upland rice, corn, fruit trees, banana, and root crops. The rest is either cogonal, secondary forest, or primary forest. Coconut grows well along the coast in this soil (Fig. 24). In Camiguin Island, coconut is planted to as high as 1,200 feet elevation with good growth. Because of the presence of boulders in the surface layer, this soil especially the rolling area can be devoted to the growing of permanent crops, such as fruit trees, and coconut.

ALIMODIAN SERIES

The soil of the Alimodian Series is developed from the weathering of stratified shales and sandstone. The surface layer is brown to light brown and reddish brown, slightly friable clay loam, and the subsoil is light brown, slightly compact clay loam. Fragments of shales and sandstone rocks occur on the surface, and layer of stratified shales and broken sandstone rock may be near the surface. The relief ranges from undulating to strongly rolling hilly areas, and the drainage is good to excessive throughout. Sheet erosion is severe in cultivated area on the steeper slopes and on the hill slopes which are bared of vegetation. Alimodian clay loam is the soil type mapped.

Alimodian clay loam (126).—A total of 9,729.99 hectares of this soil was mapped mostly in the eastern part of the province to the border of Agusan Province. Because of erosion, the surface soil varies in thickness as well as the color. The normal depth of the surface soil is 30 centimeters. However, one finds that in some areas the surface soil is less than 10 centimeters deep and in other places, this has been removed and what is exposed in the surface is the subsoil. The eroded areas

have lighter color of surface soil than the uneroded areas. This type has the following profile characteristics taken from a cut about a kilometer from the Agusan boundary.

Depth of the soil cm.	*Characteristics*
0- 30 —	Surface soil, brown to reddish brown clay loam, loose, good medium granular structure, slightly friable when moist, hard and brittle when dry, fair in organic matter content. and affords good root penetration. In places, broken shale and sandstone gravels are found on the surface. Boundary into the subsoil is clear and smooth.
30- 60 —	Subsoil, light brown clay loam, slightly brittle and moderately compact, poor in organic matter. Has a clear and smooth boundary with the substratum.
60-150 —	Substratum, gray to grayish-brown highly weathered shales, and weathered sandstone, weak coarse platy and slightly compact. Shale and sandstone are stratified in places.

About 30 per cent of this soil is cultivated and the most important crop planted is coconut. Other crops are upland rice, corn, camote, cassava, gabi, vegetables, banana, and some fruit trees. The rest of the area is either cogonal or secondary forest.

Crop yields in this soil are low, due to a greater extent to the badly or seriously eroded soil that in many places the unproductive subsoil, or the layer of stratified shale is exposed to the surface. And also to the fact that the soil is very much deficient in the readily available nitrates and potassium, besides the prevailing improper methods of cultivation.

This soil, however, could be brought to yield a reasonable high level and economically profitable crop by adopting proper farm practices that would promote the best of the soil conservation and allow soil fertility to develop. For this reason, heavy application of nitrogenous and potassic fertilizers should be done to correct the deficiency in nitrogen and potassium. The liberal application of organic matter, crop rotation as well as green manuring are farm practices essential for the permanency and stability of soil fertility. The erosion damage could be minimized or avoided by the use of contour plowing, strip and contour croppings, and terracing.

Mountain soils undifferentiated (45).—The soils classified under the mountain soils undifferentiated are rough mountainous regions which are difficult to survey because they are hardly accessible. A total area of 111,883.09 hectares or

28.56 per cent of the total area of the province is mapped. They occupy the high mountains and the rough hilly and mountain ranges bordering Lanao, Bukidnon, and Agusan Provinces. Most of the areas are in forest. The cleared areas are cogonal. These soils are of no immediate agricultural value for the present and they should be left as cogonal and forest.

VII. MORPHOLOGY AND GENESIS OF MISAMIS ORIENTAL SOILS

The soils being the product of the forces of weathering and soil development on the parent materials give rise to many soil types with diverse characteristics. We find some soil types having one or more distinct differences from one another. There are soil types which are broadly different in many respects, aside from the wide areas whose soils may be similar but manifest distinct differences in characteristics.

These various characteristics and differences of soil types are due primarily to the influence of (1) the composition of the parent materials, (2) the climate under which they are formed or existed since accumulation, (3) the plant and animal life in the soils, (4) the relief of the land, and (5) the length of time the forces of development have acted on them.

The climate of Misamis Oriental is not uniform throughout the province. It is characterized by two types of rainfall: no dry season with a very pronounced maximum rainfall in the eastern part and no very pronounced maximum rain period with a short moderately warm dry season in the central and western parts. The moderately high temperature favors rapid chemical reaction under moist condition. High rainfall influences intense leaching of soluble materials, as alkalies and alkaline earths.

The general relief is from level lowland, undulating, flat upland, rolling, hilly, and mountainous. The surface drainage in the level lowland is poor to adequate and good to free and excessive in the rolling and hilly to mountainous regions.

The soils had been developed mostly under forest cover. But when men started to work the land many changes had occurred, that the present vegetation besides the forested areas, are second growth, cogon grass, and permanent fruit trees. In the cultivated areas, there has been little chance for the accumulation of organic matter in the soil. In the forested and cogonal areas, a thin covering of leafmold or forest debris is on the surface and the A horizon may contain enough organic matter.

The parent materials have different physical and chemical compositions. The hills along the coast and the rolling areas above the coastal plains are Tertiary sedimentary rocks, such as, limestone, sandstone, conglomerates, and limy shales. The higher uplands, hills, and mountains are of igneous rocks, mostly intermediate to basic flows with some agglomerates and ash beds. Undifferentiated metamorphic rocks like slate, schist, gneiss, and quartzite are found in some hills and mountain regions. And as a result of these wide variations in rock formation, several distinct soil series have developed. In some cases, similar parent materials have given rise to more than one soil series.

The soils of Misamis Oriental are primary soils and secondary soils. The primary soils are formed in place through the weathering of the parent materials. The flat upland, the rolling areas, the hills, and the mountains are the primary soils. They have well developed profile characteristics. The secondary soils are those transported by water and wind. These are the alluvial soils of the plains and valleys which have been deposited at different times. They have undeveloped to slightly and moderately developed profiles. On the basis of topography, mode of formation, and kind of profile, six profile groups of soils are established in Misamis Oriental as follows:

Profile Group I
1. Coastal beach sand.

Profile Group II
1. Umingan series
2. San Manuel series

Profile Group III
1. Bantog series
2. Matina series
3. Mambajao series

Profile Group VII
1. Jasaan series
2. Camiguin series

Profile Group VIII
1. Alimodian series
2. Lourdes series

Profile Group IX

1. Faraon series
2. Bolinao series

Profile group I are the soils having undeveloped profile. These are young alluvial fans, flood plains or other secondary deposit. Beach sand which has an undeveloped profile of a layer of fine to coarse structureless sand represents this group.

Profile group II is represented by Umingan and San Manuel series. These soils are young alluvial fans, flood plains or other secondary deposits with a slightly developed profile underlain by unconsolidated materials. The profiles of these soils are much more developed as compared to the beach sand. The Umingan and the San Manuel series, while, they belong to the same profile group have distinct differences from one another. The Umingan series for example has a layer or layers of gravels and stones accumulation in the profile which is absent in the San Manuel series. This gravel and stone accumulation is a distinct characteristic of the Umingan series. Both soils are well suited to lowland rice and other farm crops and have more or less similar physical land characteristics.

Profile group III includes soils on older alluvial fans, flood plains or terraces having moderately developed profiles (moderately dense subsoils) underlain by unconsolidated material. Bantog, Matina, and Mambajao series belong to this group. These series have their parent materials deposited for long period of time and thus have their profile moderately developed. Their physical land forms are similar but their internal characteristics as well as their soil colors are different. These differences may be due to the differences of their parent materials. The Matina series has dark to almost black surface and subsoils. It is developed on parent material washed down from hilly areas of shale and limestone formation. Some shale and limestone gravels are found in the surface. The Mambajao series has light brown to reddish brown surface and subsoils. Its parent material originated from hilly areas of andesite and volcanic formation. Bantog series on the other hand has a brown, dark brown to grayish brown surface and subsoil. This soil is developed from parent material of basalt, and andesite formation. These soils are dominantly clay and have slow internal drainage. They are deep soils.

Profile group VII includes upland soils developed on hard igneous rocks. Jasaan and Camiguin series are classified under this group. They have developed from basalt and andesite rocks under a flat upland, rolling, hilly, and mountainous topography. These soils are fairly deep and the reddish color of the soils is a characteristic of Philippine soils developed under similar topographic and climatic features like the Tugbok soils of Davao and the Luisiana soils of Laguna.

While these soils have been developed under similar conditions and from similar parent materials, yet externally and internally they manifest distinct differences in characteristics. The Camiguin series is characterized externally by the presence of big boulders and rock out-crops which interfere in the cultivation. These boulders are embedded in the profile to as deep as one and one-half meters form the surface. This characteristic is generally absent in the Jasaan soils.

Profile group VIII are soils on upland areas developed on consolidated sedimentary rocks. These are the soils that have been formed on stratified rocks, such as, limestone, sandstone, and shale. This group is represented by the Alimodian and the Lourdes series. The Alimodian soil had been developed on stratified rocks, such as, sandstone, and shales under topographic features of rolling, hilly, and mountainous. The vegetation is from the parang type to forested. Closely associated with this soil is the Lourdes soil which had been developed from metamorphic and sedimentary rocks like sandstone and shales. These are primary soils formed in place through the forces of weathering and soil development on the parent materials.

Representing profile group IX are the Bolinao and the Faraon series. These soils had been developed on consolidated rock materials like limestone having a rolling, hilly and mountainous relief. These two series, although, under the same profile group and developed under similar topographic and climatic features with similar parent materials, have distinct differences. Faraon series on one hand has a soil of dark brown to black and a highly weathered limestone rock of yellowish-gray color. On the other, Bolinao soil is brown to reddish brown and a reddish brown highly weathered limestone rock. These differences in the color of the soils and the highly weathered limestone rocks may be attributed to the chemical composition of the parent materials. Bolinao limestone may contain more of the iron elements than that of Faraon limestone.

The mechanical analysis of the soil samples of the different soil series is shown in table 10. This table shows that the soils of Misamis Oriental contain high percentage of clay. The highest is Matina soils with 79 per cent clay followed by the Bantog soil with 69 per cent clay, and the lowest is San Manuel soil with 15 per cent clay. This high clay content of the soil is expected because the parent materials are of the clay forming soils. The parent material is one of the factors that influence soil formation.

The pH value ranges from strong acid of the Jasaan soils to slightly acid of the Faraon and Bolinao soils. The acid reaction of the Jasaan and the other soils may be due to the climatic condition of the province which because of heavy rainfall there has been leaching of soluble materials, as alkalies and alkaline earths. On the other hand, Bolinao and Faraon soils are developed from limestone, hence slight acid reaction.

VIII. PRODUCTIVITY RATINGS OF MISAMIS ORIENTAL SOILS

The productivity ratings of the soils of Misamis Oriental are shown in table 11. The ratings are based on estimates, interviews with farmers, municipal agricultural inspectors, provincial agricultural supervisors, and also from bulletins, pamphlets, census, statistics, and other publications on the agriculture of the province. These estimates are on current practices without the use of amendments and are considered to be as precise as can be established and that they can serve to show the relative productivity of the soils of the province. However, they may not apply directly to a specific tract of land for any particular year because the soils shown on the map are not of the same fertility, neither the management practices are similar from farm to farm, and that the climatic conditions fluctuate from year to year.

The rating of each of the soils for each crop is compared to a standard of 100. This standard index represents the approximate average hectare yields obtained on the more extensive and better soil types of the regions of the Philippines without the use of amendment. An index of 50 shows that the soil is about half as productive for the specified crops as the soil with the standard index. On the other hand, an index

of 120 indicates that the soil is quite more productive for the specified crops as the soil with the standard index.

The soil types are arranged in the productivity table in the order of their general productivity under prevailing farming practices. This arrangement of the soil types is not a measure as to the importance or suitability of certain soils for the particular crops and it should not be given too much significance for that matter. The arrangement is presented to give information as to the general productivity of each soil of Misamis

TABLE 11.—*Productivity ratings of the soil and physical land classification in Misamis Oriental*

Soil types[1]	Crop productivity index[2]							Physical land classification[3]
	Coconut 100=3750 nuts per Ha.	Corn 100=17 cavans per Ha.	Rice: Lowland 100=60 cavans per Ha.	Rice: Upland 100=20 cavans per Ha.	Abaca 100=15 piculs per Ha.	Tobacco 100=1475 kilos per Ha.	Banana 100=900 bunches per Ha.	
San Manuel loam	110	75	85	—	—	85	95	First class soil
Umingan loam	110	75	85	—	—	85	95	
Bantog clay	100	75	85	—	100	—	90	
Mambajao clay	110	80	80	100	170	—	100	Second class soil
Matina clay	110	75	80	—	—	65	80	
Umingan clay loam	95	70	85	—	—	—	85	
Jasaan clay	95	85	—	200	170	75	85	Third class soil
Jasaan clay loam	95	80	—	200	170	—	85	
Alimodian clay loam	95	50	—	60	—	65	75	
Bolinao clay	105	50	—	75	—	80	100	Fourth class soil
Faraon clay	105	50	—	75	—	75	100	
Lourdes clay loam	80	50	—	50	—	65	60	
Camiguin clay	100	45	—	—	—	—	65	
Jasaan-Bolinao complex	95	45	—	60	—	—	85	Fifth class soil
Jasaan clay, stony phase	75	45	—	—	—	—	65	
Mountain soils undifferentiated	—	—	—	—	—	—	—	

[1] Soils are listed in the approximate order of their general productivity under current practices and their relative physical suitability for growing crops.

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

[3] This is a grouping of the soil types and phases according to their relative physical use adaptability under Misamis Oriental conditions.

Oriental. The productivity ratings are to supplement the description of each soil type in the soil survey report to show briefly in a summarized form the previous performance of the soils as to crop yields in relation to their external and internal characteristics.

As shown in table 11, the soil types that give the highest production in coconut are San Manuel loam, Umingan loam, Mambajao clay, and Matina clay. For corn is Jasaan clay followed by Jasaan clay loam and Mambajao clay. San Manuel loam, Umingan loam, Bantog clay, and Umingan clay loam give the best production in lowland rice followed by Mambajao clay and Matina clay. Jasaan clay and Jasaan clay loam come first in the production of upland rice; and for abaca Jasaan clay and Mambajao clay surpass the others. San Manuel loam and Umingan loam excel the rest in tobacco production while Mambajao clay, Bolinao clay, and Faraon clay are the best for banana.

It will be noted that the relative importance of a soil for growing crops is not so much of the productivity as measured by yields. In table 11, the soils of Misamis Oriental vary in their production of the major crops considered. This is significant because productivity of the land is affected by several factors, principal among which are climate, soil, (including physical, chemical, and biological characteristics), slope, drainage, and management, including the use of soil amendments. These factors, while they do not operate separately from the others, one or more may dominate.

The ease or difficulty of tillage as influenced by steepness of slopes, presence or absence of stones, and the textural characters of the soils are some physical characteristics that determine the suitability of soils for agricultural use. On the other hand, the ease or difficulty of maintaining productivity is due to fertility, susceptibility to erosion, water-holding capacity, and permeability to roots and water. There is also the natural hazard of insect pests and diseases. While data on this case are not available, it can be assumed that they cause the reduction of yields of some crops more than the other. It is therefore, important that in a plan of land classification to designate the relative worth and suitability of land for agricultural use, the productivity as measured by yields should not be considered alone. The factors that influence the yields should be given a full recognition as well.

Table 11 also shows the physical land classification. The soil types and miscellaneous land types are grouped into first, second, third, fourth, and fifth class-soil based on their relative physical suitability for use. The grouping of these soils is to give information regarding their physical adaptation in the present agriculture of the province. Under Misamis Oriental condition, first-class soils are good to excellent crop-lands, second-class soils fair to good-crop lands, and third-class soils fair croplands. Fourth-class soils are physically unsuited for farm crops, although they are generally best fitted to pasture. When used as cropland especial soil conservation measures should be employed. The fifth-class soils include lands best suited for forest and in some cases for pasture.

Mambajao clay is placed under the third-class soils although, it is one of the soil types that gives the best production for the different major crops considered in the productivity ratings. This is because its physical land feature is from level to sloping and moderately rolling. This soil requires intensive soil conservation practices aside from the ordinary practices. The high production may be accounted for by the most favorable climatic condition where this soil occurs.

IX. LAND USE AND SOIL MANAGEMENT

Efficient utilization for the use of land, implies fundamentally, proper organization and complete coordinated plan to achieve economic yields "to bring about better land use, better life for the people living on the land, and protection of public welfare." When the utilization of land is maladjusted, it follows that the land use itself is maladjusted and therefore, economically inefficient. This is a basic and primary problem in the use of land in agriculture.

The province of Misamis Oriental is predominantly dependent on agriculture. But much of her agricultural practices are still primitive, the crude methods used by our forefathers, and yield less. It is the chief concern of the people to make proper change and adjustment of their farm practices to increase food production and greater diversification of cash crops. It is a sad fact that since the early days to the present, the province has not been self-supporting in the production of her staple food. Although rice is the main food crop, she has been importing this cereal every year from other provinces. To remedy this situation, it behooves the farmers that the agriculture of the province should be placed on a modern level directed towards an efficient utilization for the use of the land. The individual farmer should be encouraged to use in their farms, measures and practices whereby soil fertility will be preserved, water supply safely guarded, erosion and devastation prevented, so that the highest possible agricultural production is achieved.

Use of the land in Misamis Oriental has always been guided and based essentially by the physical character of the land, but it has not been unusual or strange to see incorrect use of the land. There are those heavily eroded lands and steep to hilly relief placed under cultivation. There are lands in crops which are not all normally suited for cultivation as regard to permanent land use, and there are also lands under forest or pasture which normally and physically are fitted to the cultivation of farm crops. These are few examples of the misuse of the land in the province.

Misamis Oriental is one of the provinces of the country so hilly and mountainous that arable lands are to be found in the narrow plains along the coast and river valleys. The land's topographic character may be divided into three general features, to wit: (1) the hilly and mountain regions (24 per cent of the total land area of the province); (2) the rolling area (60 per cent); and (3) the coastal plains and river valleys (16 per cent).

The hilly and mountain regions are delineated as undifferentiated. Some are too steep for profitable production of crops and neither can they be used for pasture purposes. Others are thickly forested that for the present time they have no immediate agricultural value.

The rolling area constitutes the land of the province where specific farm practice and soil management should receive full consideration as guides for their utilization to obtain economic yields. Their relative suitability for agricultural use must give recognition of the factors that influence the yields. Under this area are the soils of the Jasaan, Camiguin, Bolinao, Faraon, Lourdes, and the Alimodian series. While these soils could be utilized for the growing of some farm crops, as is now being practiced, their cultivation should be conditioned under special soil management practices to protect them from soil erosion and to maintain soil productivity at a given level. These soils are better adapted to pasture land and permanent crops, such as, fruit trees, coconut, abaca, and banana, rather than use them as crop lands, and if properly managed as pasture

land or permanent crops they are capable of giving more returns than when used as crop land. Since the coastal plains and river valleys for cropland areas are very limited, the people have no recourse than to farm these soils. Their cultivation should, however, be based on a well planned program of soil conservation, such as terracing, contour plowing, strip cropping, crop rotation etc., to prevent them from being eroded or depleted.

Along the coast of the province, the hilly and rolling areas are permanently planted to coconuts, fruit trees, or ipil-ipil. This method is a correct practice because the surface of the land has cover and the top soil is less exposed to erosion. Further inland, a great portion of the rolling areas is more or less permanently cultivated to upland rice, corn, and other food crops. The up-and-down-slope plowing prevails. Even the newly cultivated areas along the the slopes are placed in the kaingin system of farming. This system of cultivation is prejudicial to the land and greatly hastens soil erosion.

It is not uncommon therefore, to see in the province of Misamis Oriental the improper land use and soil management being practiced in the rolling areas. A large portion of these areas should have been under vegetal cover by devoting them to the culture of permanent crops. All those areas that have been kept for the cultivation of seasonal crops, like those having gentle slopes should have been tilled using soil conservation practices. Some of the soil conservation farming practices are contour tillage, contour strip cropping, contour buffer strip planting, contour furrowing, terracing, cover cropping, and well planned crop rotation.

One of the primary needs of these soils is a large supply of organic matter. The addition of same is of prime importance. The organic matter aids in the retention of moisture and also supplies plant nutrients. The planting of legume crops, such as, cowpeas, soybeans, mongo and beans in rotation with rice or corn and then plow them under as green manure is a good source of organic matter besides increasing the nitrogen of the soil. The liberal application of farm manures will also help supply part of the organic matter needed by the soils.

The coastal plains and river valleys are considered the most important agricultural soils of the province. They are of recent alluvium and could be farmed with little difficulty and responds readily to good management. They are suitable for continuous cultivation of seasonal crops without endangering them to soil erosion, and with the use of the ordinary method of farming, such as, application of fertilizer, green manuring, crop rotation, and good tillage operation, are capable of being built up to a fair or high state of productivity. The area, however, is relatively small and it includes the San Manuel, Umingan, Bantog, Matina, and Mambajao series. More than 50 per cent is permanently planted to coconut and the rest to rice, corn, and other food crops. While these soils are of recent alluvium they have been long under cultivation without the benefit of soil conservation practices hence, have naturally been depleted of their fertility. The practice of growing one crop on the same land year after year giving no regard to improving or maintaining soil fertiilty is faulty. Liming, fertilization, crop rotation, and addition of organic matter are entirely disregarded. Even the coconut trees which are permanent crops seem to be under nature's care. Some plantations are not weeded. All are not cover cropped. As a result of the faulty farm management prevailing in the province, there could be expected no other consequence but low production. As a matter of fact, the farmers realized it in their farms that they have been experiencing a marked downward trend in crop yields. Of course, there are some factors that influence this decrease, but it could not be denied that farm management practices are quite primitive and play an important part in the decrease of the crop yields. On the other hand, it has been shown that with the proper innovation in farming there has been noted a marked increase in yields.

X. WATER CONTROL ON THE LAND

One important agricultural aspect for secure crop production is the control of water on the land, failure of which may mean undue adverse effect on the productive capacity of the land. Uncontrolled amount of water in the soil and the run-off on the land have been recognized to ultimately influence poor crop yields and the corollary effect on increased soil erosion. Under any prevailing improper method of land cultivation, soil erosion is tremendously accelerated, but where the methods of land cultivation suit the land, there is little if any soil erosion taking place. Thus, it is very necessary to emphasize the proper use of the land and the correct soil management to the

farmers for permanency and stability of their soils to insure the economic welfare of the whole region.

In Misamis Oriental Province, any effort directed toward the control of run-off and the resulting erosion should be calculated on a program to harmonize farming system with the general relief of the land, the condition of soils, and the climate. This is important because the active agent of soil erosion in the province is water, and soil erosion in this place is enhanced through incorrect land use and poor soil-management practices. Incidentally, there are farming systems, inherently soil and water conserving, adapted to the physical condition of the land and their implementation provides to make possible the most effective control of run-off. Precipitation in the province is quite heavy for at least six months of the year and the intensity of rainfall during this period does an enormous amount of damage to the plowed lands and bare lands by erosion due to unrestrained run-off.

The topographic character of the land of the province has been divided into three general features, viz, the hill and mountain regions, the high upland and rolling areas, and the coastal plains and river valleys. They are discussed at length in the preceding pages, including their land-use, soil and water conservation, and proper soil management for the best economic yields of crops. The hill and mountain regions which are classified mountain soils undifferentiated in this report have either grass and secondary, or thick primary forest covers. Under these vegetal covers they are safe from the inroads of soil erosion because the flow of run-off is so regulated by their vegetal covers.

The coastal plains and river valleys are primarily devoted to the major row crops of the province. Erosion in this type of relief is not so much a problem because of uniform run-off due to the almost flat relief. Besides, the fields are divided into paddies by dikes controlling the flow of water from one paddy to another. On the other hand, due to the absence of irrigation maintenance, an economical and fair distribution of water supply is vital. The ordinary method of farm practices would maintain effectively soil moisture in this kind of relief.

Run-off, however, is a problem in the high upland and rolling areas comprising about 60 per cent of the total area of the province. Due to the irregular topography and generally most parts are devoid of effective forest covers in addition to their being cultivated the soils are subjected to varying degrees of sheet and gully erosion. The gullies are deep and numerous. The cultivated area is under clean culture, a practice which favors free run-off. Areas having slopes even greater than 30 per cent are cleared and cultivated. Uncultivated portions are in most parts under cogon grass are bare of covering, and run-off is rather excessive.

It is obvious that the condition of erosion in Misamis Oriental Province is serious that the task of controlling run-off is imperative and should be given an immediate attention. The special conservation practices discussed and recommended in the section of Land-use and Soil Management in the preceding pages hold equally well as effective measures to regulate the flow of run-off in this type of relief, thereby preventing soil erosion and conserving soil moisture. Where the hills and high uplands are bared of covering, reforestation should be undertaken. Such step is designed to provide the land with beneficial covers to offset the danger from erosion by arresting the flow of run-off.

II. SOIL EROSION SURVEY OF MISAMIS ORIENTAL

The reconnaissance erosion survey of Misamis Oriental was conducted simultaneously with the soil classification and mapping of the province to (1) give a picture of the different degrees and extent of soil erosion in the province; (2) present the different factors that cause soil erosion; (3) show the effect of erosion to agriculture and the country; and (4) to suggest possible remedial measures to control or check soil erosion. The data gathered in the survey show that the lands of the province vary in their erodibility and response to remedial measures and management.

KINDS OF SOIL EROSION

Soil erosion may be defined as "a geological process that removes or wears away soils and geologic materials from the land surface through the actions of natural agencies, primarily water, wind, and gravitational creep." Accordingly, there are two main groups of soil erosion recognized—normal or geological erosion and accelerated erosion.

Normal or geological erosion.—Normal or geological erosion is a process by which soil particles are removed under natural conditions operating through long period of time. It has been going on for ages. Under this condition, it is considered a part of the whole complex soil making process, that is, the loss of the topsoil through this kind of erosion is balanced through soil formation from the materials beneath. This is beneficial rather than destructive erosion.

Accelerated erosion.—Accelerated erosion is made possible due to man's activities. It removes soil materials very much faster than the soils are formed from the material beneath. This kind of erosion is the "most dramatic and disastrous of the evil things that can happen to the soil." It makes agriculture deplorable by converting fertile fields into waste lands. The valuable topsoil containing all the essentials for a productive soil is lost and the capacity of that soil to produce is lessened. When both the topsoil and the subsoil are lost exposing to the surface the underlying bedrocks below that soil has very little if there is any left to work with. The land is practically ruined and whatever agricultural practice is employed, has no more worth or use. However, if the soil there is retained, it can be made highly productive through the employment of good and proper farming management.

Accelerated erosion in Misamis Oriental is caused mainly by running water, and perhaps to a very little extent by wind. The latter takes place only along the shore and hence, is very insignificant.

Water erosion is the most important of the accelerated erosions and is responsible for the depletion and destruction of vast, good, and fertile agricultural lands. This is the result from the forces of flowing water that erodes the surface soil which has no adequate protection. Water erosion are of four forms: viz, sheet, rill, gully, and stream-bank erosion.

Sheet erosion.—Sheet erosion is defined as a more or less uniform removal of soil from an area without the development of conspicuous water channels. It is hardly noticeable in the field during its earlier stages. But it covers a wide area and is the most destructive. This erosion, varies among soil types and on different slopes of unprotected soils.

Rill erosion.—Rill erosion is another form of water erosion which refers to the removal of soil through the cutting of numerous small but conspicuous water channels or tiny rivulets that are minor concentration of runoff. Tillage operation easily erases these shallow channels. This is not as destructive as the sheet erosion.

Gully erosion.—This form of water erosion is the removal of soil resulting from the formation of relatively large channels or gullies cut into the soil by concentration of run-off. It is the most conspicuous among the water erosions and any one can recognize it even from a long distance. Locally it is destructive but affects a much smaller total area of arable soil and does less damage on most farms than sheet and rill erosions. Gullies are developed in exposed natural drainage way, in depressed irregularities in plow furrows, animal trails, between rows of crops that run up and down the slopes, etc. Deep gullies are not even crossable with the common types of farm machinery and form barriers that subdivide fields into smaller units. However, gully erosion affects a much smaller total area of arable soil and does less damage on most farms than sheet and rill erosions.

Stream-bank erosion.—This form of water erosion is caused by the cutting away of the soil along the bank of a stream hurrying on its way. Run-away stream wears down its banks and is generally severe at the outer bends of the loops it forms (by the stream) as it flows around or winding (flow) through meadows or pasture. At normal time, water in the stream is slow and does not do any damage but when flood or storm occurs, the stream rushes so rapidly and does lots of damage and even changes its course hundreds of feet destroying the lands on its path.

FACTORS AFFECTING SOIL EROSION IN MISAMIS ORIENTAL

There are several factors that affect the extent and severity of soil erosion in any given area. In Misamis Oriental, the following are the most important, to wit: climate, slope, soils, vegetation, and land management.

Climate.—Climate is one of the primary factors in soil development and incidentally the main agent that renders the soil desolate. It influences erosion hazards and to it is attributed many basic changes in soils. The loss of surface soil materials by hundreds of tons of soil per hectare, the reduction in the organic matter content, change in structure, a reduction of the producti-

Fig. 23.—Hills dissected by gullies. It is typical of the rolling areas of Misamis Oriental.

Fig. 24.—Stream bank erosion is one of the forms of water erosion. The above picture (background) shows how stream bank erosion had destroyed agricultural land on its ways.

vity level, and a change in the moisture relations of the remaining soil are primary changes brought about by climate as a result of erosion.

Rainfall and wind which are chief elements of climate are the two principal agencies of destructive soil erosion. In many countries, topsoil may be completely removed from the land by runoff just as by wind. In the Philippines, however, especially in Misamis Oriental, wind erosion is very insignificant in contrast to runoff or water erosion. Runoff removes the surface soil and also produces channels or furrows in the surface that through hollow-cut process widen into gullies and become a serious hazard to tillage operations.

The nature of rainfall influences the differences in the degree of erosion. Rainfall of greater intensity for shorter period generally washes away more surface soils on the land than gentle rainfall falling over a longer period of time. Heavy downpour results to excessive runoff because the soil can not absorb it readily and does considerable erosion damage. On the other hand, a gentle rain gives a greater chance for the soil to absorb it and thereby there is less surplus water as runoff and little erosion damage.

The climate of Misamis Oriental has been fully discussed in the beginning of the report. Accordingly, based on the rainfall distribution of the Philippines, the Second Type and the Third Type or Intermediate Type A occur in the province. The second type has a mean annual rainfall of 2,461.7 millimeters in Mambajao as compared to the Third type which has a mean annual rainfall of 1,603.3 and 1,659.5 millimeters in Cagayan de Oro City and in Balingasag, respectively. October to January are the months of heavy rainfall for the second type while for the third type, it is from June to October. The mean annual minimum temperature of the province is 20.4°C, and 33.4°C is the mean annual maximum temperature. There has not been any remarkable or destructive typhoon that occurred in the province.

Slope.—The surface shape of the land limits the degree of erosion. That is, significant physiographic units or land forms have major sets of slope groups, and each set of slope groups has a different extent of erosion from the other sets of slope groups. For example, a nearly flat land having an average slope gradient of less than 2 per cent is not so much affected by erosion as a similar soil type of undulating land with an average slope of 5 per cent gradient. A rolling land with an average of 15 per cent slope gradient is much more affected by erosion than any of the first two sets of slope. On the other hand, erosion losses is less in this set of slope when compared to lands with 50 per cent slope gradient or with steep slopes. This is because the velocity and volume of runoff is directly influenced by the slope gradient of the land. Thus the higher the slope gradient, the greater will be the velocity of surface runoff, and since the power of water to scour or erode the soil is determined by its velocity and volume, a fast moving water has a greater eroding power and carrying capacity than slow moving water.

In Misamis Oriental about 254,059 hectares or 59.76 per cent of the total area of the province vary in their degrees of slopes and as such are under different erosion classes. About 129,128 hectares, or 33.17 per cent, are also within this category, but owing to the fact that they are presently under thick forest and grasslands, soil removal is balanced with soil development. If and when these lands will be cultivated they would become seriously to severely or excessively eroded under faulty management.

Soil.—Soils vary in their susceptibility to erosion and the amount of erosion that may be expected depends upon the erodibility of that soil under a particular condition. The physical character of the soil influences its erodibility. Soils of loose surface layer underlain by a dense subsoil of low permeability are susceptible to water erosion more than soils of rapid surface and subsoil permeability. Erosion is also severe on soils of high silt content, weak sandy soils, stiff clays and soils deficient in organic matter. But soils of high water absorbing power, rapid water permeability and containing sufficient amount of organic matter are relatively resistant to erosion. Organic matter in the soil increases the water holding capacity and promotes granulation thereby allowing more water to move downward and consequently reduces the surface runoff.

Some soils are erosive, although they have a very gentle slope, when exposed to sudden rains could erode rapidly. However, other soils with sufficient permeability of its different horizons, allow the downward movement of water faster into the ground and less runoff over the surface when exposed to heavy rains, even if the slope is steep. Runoff to a great extent

Fig. 25.—The configuration of the land affects erosion. The picture above shows the foreground is level and no apparent erosion. The hills in the background are seriously eroded.

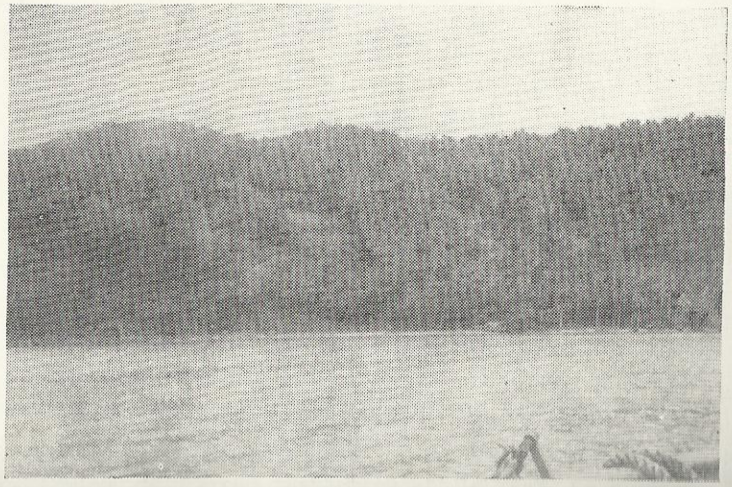

Fig. 26.—Vegetation is an effective protection of soil against erosion and the sloping areas should be under thick vegetation like the picture above.

is regulated by the rate at which water enters the surface soil and percolates to lower depth. That is, runoff is usually great during a high intensity and short duration of rain if the soil is slow in taking in, and transmitting water to its lower horizons.

The soil texture and structure also influence erosion. Heavy soils which are very sticky and very plastic when wet are strongly resistant to the passage of water and during heavy rains promote high runoff. Whereas, soils that are friable, loose, and have good granulation in all their horizons are very pervious to water so that even during heavy rains water percolates easily to the lower depth and little is left as runoff.

Vegetative cover. — Vegetation helps in the development of soil and also protects it from being eroded by water and wind. Experimental results show that unprotected soils are easily affected by erosion. They also indicate that soils containing high amount of organic matter and humus are less susceptible to erosion than soils of low organic matter and humus content. Vegetations keep the soils firmly in place. They die and decay and are incorporated into the soil as organic matter and humus. This eventually improves the soil's fertility and power to absorb water.

Improper cultivation and grazing reduced a large portion of the natural plant cover that originally protected the soils from the destructive effects of erosion by water and wind. The fields that have steadily lost their vegetative covers have their erosion increased. In Misamis Oriental erosion has increased on many soils owing to improper cultivation on the land. This is especially true on the sloping and rolling areas where the management practices are faulty allowing too much run-off. The moment the land surface has lost its protective cover as a result of cultivation, it becomes directly exposed to the abrasive action of the elements. Growing plants effectively protect the soil against erosion in the sense that they cover the surface. Land covered with thick forest or of grass is safe from erosion of either rain and wind. Even if there is run-off the debris or the sod lessens its velocity and does not move the soil so readily. On bare land, the raindrops easily break up the soil granulation which causes the pores in the soil to be clogged thus increasing the tendency for more runoff.

Land management. — Proper land management does not only help maintain or improve the productivity level of the farm but also tends to increase the yields per hectare. On the other hand, improper farm management practices enhance soil erosion and soil deterioration. Continuous loss of soil from cultivated lands in Misamis Oriental, and this is also true to all parts of the country, is due to a greater extent to improper management practices and the misuse of the land. If erosion is to be minimized in cultivated lands and agriculture is to be permanent, the management practices must be such as to conserve the soil from deterioration of its fertility through erosion and to cultivate only those lands adapted to agricultural purposes.

The land area of Misamis Oriental adapted to continuous cultivation which is not subject to erosion is approximately 27,714 hectares or 7.07 per cent of the total area of the province, and about 6,531 hectares or 1.66 per cent are appreciably affected by small extent of sheet erosion. The pressure of the growing population of the province however, which had increased from 126,788 in 1918 to 369,671 in 1948 or 191.56 per cent has rolling lands, and even the steep lands and hill slopes have been brought to cultivation. Forests were cut down and grasslands plowed under disregarding the suitability of the land to agriculture. Conservation practices were not followed and the consequence is shocking. Many of these lands have become rugged because of numerous gullies that had badly cut and their surface soil completely eroded. Other areas owing to their deteriorated condition cannot be profitably used for agriculture and were abandoned.

The cultivation of the steep lands has been done due to lack of suitable agricultural land in the province as a result of the increase in population. In many cases, farmers followed clean-tilled cropping system of planting corn and rice in these areas, a system which enhances erosion and detrimental to the land. Such areas should be retired to permanent cover for erosion control. In the first place, they should have not been cleared nor cultivated. The "kaingin" system of farming is another faulty method in agriculture being practiced and should be suppressed or stopped in Misamis Oriental. This centuries old system of farming is one of the main causes of soil erosion and deterioration of the lands of the province.

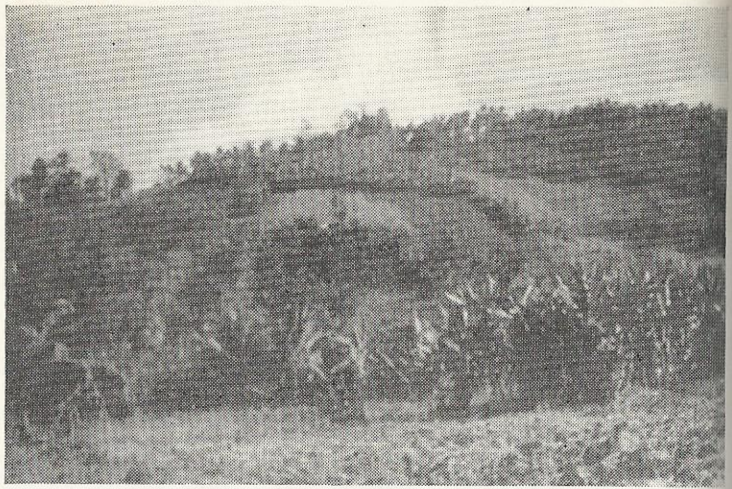

Fig. 27.—Kaiñgin system of farming is a faulty farm practice. It is one of the main causes of soil erosion. The above picture shows that part of the hill slope is under kaiñgin.

Fig. 28.—Picture shows the typical relief of Lourdes clay loam. Slopes vary from 0 to 100 per cent. The degree of erosin varies widely.

SOIL EROSION SURVEY METHOD

Soil erosion survey method consists of estimating erosion and mapping eroded soils primarily caused by the forces of water and wind. The system of classification followed in the reconnaissance soil erosion survey of Misamis Oriental was based on the United States Department of Agriculture Soil Conservation Survey Handbook and Soil Survey Manual, and on the Soil Erosion in Missouri.

Each soil has a standard which was made for a reference in the appraisement of losses on erosion. Since a soil in a natural condition has a normal range of thickness of each horizons and the solum, they were accurately determined for use as guides to erosion losses. This is shown in the following illustration.

A virgin land and a cultivated land of the same soil have a different depth of their solums. A virgin soil may have the Aoo and Ao which may be 15 centimeters. This upper 15 centimeters of the solum has abundant roots and debris. When the whole solum of this virgin soil is examined, it would show a total depth of 100 centimeters from the surface of the Aoo down to the substratum. But where the same soil has been cultivated normally under a good management and without erosion, the depth from the surface to the substratum would be 85 centimeters. This latter figure should be the standard against which to measure erosion classes within the soil type.

In like manner similar soil slopes were measured and compared in thickness for different slope classes within the permissible range of a soil type.

When a region is well-settled it is difficult to find virgin areas of soil types. Hence, in this case the cultivated soils of known management where there is neither erosion or deposition taking place are used as standards.

On the basis of the degree of erosion and gullying of both the surface soil and subsoil, five erosion groups or degrees of erosion were identified comprising nine erosion classes. The nine erosion classes were mapped.

Erosion group is judged by the extent to which the original surface soil has been removed through sheet erosion. This is determined or estimated by a comparison between the present depth of soil profiles with the depth of comparable virgin profiles of the same type under similar topographic conditions. In cases where the virgin surface soil is shallower than the average plow depth, the lower part of the solum may be used in estimating the degree of erosion.

Erosion classes are variations of the degree of sheet erosion in the erosion group. They are established primarily because of their significance to soil use and management and are used as units of mapping. Table 12, shows the system of classification and the degree of erosion in Misamis Oriental.

TABLE 12.—*The system of classification, their description and degree of erosion in Misamis Oriental*

Erosion class	DESCRIPTION	Degree of Erosion
0	No sheet erosion, no gullying	No apparent erosion
1	Small extent of sheet erosion and no gullying. Less than 1/4 of original surface soil eroded	Slight sheet erosion
2	Moderate sheet erosion. 1/4 to less than 1/2 of the original surface soil eroded.	
22	Moderate sheet erosion. 1/2 to less than 3/4 of the original surface soil eroded.	Moderate erosion
227	Moderate sheet erosion with occasional shallow gullies. 1/2 to less than 3/4 of original surface soil eroded.	
3	Serious sheet erosion. 3/4 and over 3/4 of surface soil eroded.	
38	Severe sheet erosion. With frequent gullies. Over 3/4 of the original surface soil eroded or all surface soil and less than 1/4 of the subsoil eroded.	Serious to severe erosion
5	Excessive sheet erosion. All the surface soil and over 3/4 of the subsoil eroded.	Excessive erosion
W	Balance between soil removal and development is retained. Forested and grassland not disturbed by men.	Normal

EXTENT OF SOIL EROSION IN MISAMIS ORIENTAL

The accompanying map shows the distribution of the different erosion classes delineated in the province. Table 13 shows the extent of the various types of erosion.

As a result of the indiscriminate clearing and the improper management, accelerated erosion has taken a tremendous toll in the lands of the province. As shown in table 13, 6,513 hectares, or 1.66 per cent of the area of the province, has been slightly eroded, that is, 1/4 of the original surface soil had been already removed; 138,029 hectares, or 35.26 per cent have been moderately eroded with occasional shallow gullies, or 1/4 to less than 3/4 of the original surface soil eroded; 72,442 hectares, or 18.49 per cent, have been seriously to severely eroded, or 3/4 of all the surface soil and 1/4 of the subsoil have been eroded; and 17,055 hectares, or 4.35 per cent, have all their surface soil and including 3/4 of the subsoil have been eroded. From these data a total area of approximately 234,039 hectares, or 59.76 per cent of the area of the province, have been adversely affected by varying degrees of soil erosion and gullying.

Considering that a hectare of soil to a depth of 17 centimeters weights approximately 2,000 tons, and since 227,566 hectares of the province have been moderately to severely and excessively eroded, approximately 455 million tons of the soils of Misamis Oriental, have been lost already through surface wash and gullying from the time cultivation have started in the province.

Most of the lands adversely affected by accelerated erosion in the province are those having slope gradients of 4 per cent

TABLE 13.—*Area, percentage, and soil types under the different types of erosion in Misamis Oriental*

Degree of erosion	Average amount of original surface eroded	Soil type	Area in hectares	Per cent of land area of province
No apparent erosion	O	Hydrosol Beach sand Umingan clay loam San Manuel loam Matina clay Bantog clay Umingan loam Mambajao clay	27,714	7.07
Slight erosion	Less than 1/4	Mambajao clay Umingan clay loam Bantog clay Jasaan clay	6,513	1.66
Moderate erosion	1/4 to less than 3/4	Mambajao clay Umingan clay Jasaan clay Jasaan clay, stony phase Jasaan clay loam Bolinao clay Faraon clay Camiguin clay Alimodian clay loam	138,029	35.26
Serious to severe erosion	3/4 of surface soil to 1/4 of subsoil	Jasaan-Bolinao Complex Jasaan clay, stony phase Lourdes clay loam Camiguin clay Jasaan clay	72,442	18.49
Severe to excessive	All surface soil and 1/2 to 3/4 of subsoil	Parts of Mt. soil undifferentiated Lourdes clay loam	17,055	4.35
Normal	Soil removal is balanced with soil development	Mt. soil undifferentiated (Forest and grasslands)	129,928	33.17
	Total		391,681	100.00

and over. Due to the increase of population more and more of the rolling lands including the steep slopes and hillsides have been cultivated. And because of improper tillage and management, they eventually lost their vegetative covers, hence, erosion takes its toll. These varying degrees of erosion occur on the regions between the coastal plains and the primary forests of the mountain ranges along the eastern part of the province, mostly on the Mambajao, Faraon, Bolinao, Alimodian, Jasaan, Lourdes, and Camiguin series. Erosion is excessive on the strongly rolling areas, steep slopes, and on hillsides under clean-tilled cropping system.

SOIL EROSION IN THE DIFFERENT AREAS

The soils of Misamis Oriental were discussed in detail except the extent of their erosion in the section on soils in this report. Accordingly, there were three general groups of soils reported based on the physiographic condition of the land of the province. Each soil of these three soil groups present a certain degree of erosion, and when they are taken together would indicate the extent of erosion that has taken place in the province. The soil types under each soil group are as follows:

1. Soils of the plains, valleys, and undulating areas.
   a. San Manuel loam
   b. Umingan loam
   c. Umingan clay loam
   d. Bantog clay
   e. Matina clay
   f. Mambajao clay

2. Soils of the rolling areas, high uplands, and hills.
   a. Jasaan clay
   b. Jasaan clay loam
   c. Jasaan-Bolinao complex
   d. Jasaan clay, stony phase
   e. Lourdes clay loam
   f. Camiguin clay
   g. Bolinao clay
   h. Faraon clay
   i. Alimodian clay loam

3. Miscellaneous land types
   a. Hydrosol
   b. Beach sand
   c. Mountain soils undifferentiated

1. EROSION OF THE SOILS OF THE PLAINS, VALLEYS, AND UNDULATING AREAS

The soils in this group are secondary soils developed from recent and older alluvial deposits. They occupy generally the plains and valleys of the provinces with a relief varying from nearly level to slightly undulating. The greatest slopes of the undulating areas do not exceed 6 per cent with an average of 4 per cent. The greatest slopes in the plains and valleys do not exceed 2 per cent. Erosion on these soils vary depending on the degree of slopes and farming practices, from no apparent sheet erosion to slight and moderate sheet erosion. The undulating areas generally have moderate sheet erosion. On the other hand, there are areas within this group that receive yearly deposits of soil materials from the adjacent uplands when the rivers overflow their banks. Areas, however, along the rivers suffer from stream-bank erosion when the rivers hurry on their way during floods or heavy rain.

Erosion on San Manuel loam.—The San Manuel loam was mapped in Mambajao, Mahinog, Tagoloan, and parts of the plains in Medina, Cagayan de Oro City and Balingasag. Areas of this soil have nearly level relief with the greatest slope of about 2 per cent, and there is no apparent sheet erosion. A large area of this type receives soil materials from the adjoining uplands. However, owing to the fact that the areas of this soil are generally located along the river, it usually suffers from stream-bank cuttings when the rivers wear their banks during periods of heavy waterflow. Sometimes stream-bank erosion is serious.

Erosion control in this soil is not a problem. Part of the area is planted to rice and the dike in the fields regulate the flow of water on the surface. The other portion is planted to coconut and since the area is nearly level, erosion is not a problem. The management practices, therefore, do not influence erosion. Nevertheless, soil fertility has been depleted owing to the planting of the same crop every year without the addition of commercial fertilizer. In order to improve the fertility of this soil and maintain it to a high level, it is essential to have a good rotation system of farming combined with the application of fertilizer. Planting of cover crop specially legumes in the coconut fields is essential.

Erosion on Umingan loam.—This type of soil was mapped in Lagonglong, Balingasag and Alubijid. It has a nearly level relief. The greatest slope is about 2 per cent. This soil is loose and friable, hence the downward movement of water is good, and it also receives soil materials from the adjacent uplands and is affected by stream bank cuttings. Like the San Manuel loam, erosion control on this soil is not a problem. It is planted principally to coconut, lowland rice and corn. Areas planted to rice and corn should be managed under good rotation system of farming and combined with the application of fertilizer to maintain its high level of fertility. Areas planted to coconut should be planted to cover crop. Bananas, fruit trees, and root crops are the secondary crops in the soil type.

Erosion on Umingan clay loam.—A total area of 2,276.47 hectares of this soil type was mapped in Silay, Tagoloan, Jasaan, and Cagayan de Oro City. About one half of it is nearly level and has no apparent erosion. It is planted primarily to coconut and lowland rice. Corn, root crops and vegetables are secondary crops.

The other half is undulating with the highest slope of about 4 per cent gradient and there is a little loss of surface soil through erosion. This area is still under cogon and shrub, which are often burned during the short dry season and as a result of which about 1/4 of the original surface soil, especially in areas with the highest slope, has been removed by surface wash. Erosion control on this soil should lay emphasis on keeping intact the vegetation so that the soil should not suffer from erosion. If and when the area is tilled, however, some erosion control measures should be followed.

Erosion on Bantog clay.—The surface soil and subsoil of this soil type including the substratum are heavy, sticky, plastic, and compact clay. The permeability is slow. The relief is from nearly level to slightly sloping; the greatest slope does not exceed 3 per cent. It is planted to coconut, lowland rice, and corn.

Erosion on this soil is not apparent except portions of the area having about 3 per cent slope where slight erosion has been going on and about 1/4 of the surface soil has been lost. Good crop rotation and management of this soil are the most effective control for erosion. The rice fields are diked and the surface flow of the water from one field to the other is regulated. The coconut fields are neglected allowing slight erosion losses of the surface soil. Cover cropping with legumes of the coconut fields would minimize if not prevent these losses.

Erosion on Matina clay. — Erosion in this soil, is not apparent although the soil is heavy, sticky, plastic, compact clay, with poor permeability. This is because the greatest slope on the Matina soil does not exceed 2 percent and the average slope is even less. There is a slight deposition taking place of soil materials from the adjacent uplands in some areas of this soil. This soil type comprises the plains of Manticao and Lourdes and part of the plain of Cagayan de Oro City.

About 80% of the area is planted to coconut and lowland rice. Rice fields are diked but the coconut fields are not well kept. Nevertheless, due to its level relief there is no apparnt erosion. The uncultivated area is cogonal with some shrubs. This area also has no apparent erosion.

Erosion on Mambajao clay. — Mambajao clay has slopes varying from 2 per cent up to 6 per cent in some areas, the average being about 4 to 5 per cent. The steeper slopes include the areas above the plain in Mambajao, Catarman, Medina, Talisayan, and Quinoguitan. About 10 per cent of the total area of 22,676.90 hectares is nearly level and has no apparent erosion. The rest or about 90 per cent is moderately eroded, having 1/4 to about 3/4 of the original surface soil already lost through erosion.

The permeability is slow to moderately slow, the soil being clay, moderately compact, and slightly friable to sticky and plastic. About 70 per cent of the area is cultivated mostly to coconut and abaca. These crops help reduce erosion. In some sections of the area where the farmers practice the clean-tilled cropping system, about 3/4 of the original brown clay surface layer has been lost and few scattered shallow gullies are present. Erosion in this soil is moderate, not only because of a gently rolling relief, but also because of the poor management of the land. A small hectarage comprising the level portions is used for grains-type of farming. The uncultivated region is under cogonal and secondary forest.

Erosion controls on the Mambajao clay should undoubtedly depend on the management of the land. The areas planted to coconut need cover cropping of legumes for erosion control. The abaca plant should be planted in contour, while the areas for the grain crops should follow a system of good rotation, contouring, and terracing and the crops be habitually fertilized and limed according to recommendations.

2. SOIL EROSION ON THE ROLLING, HIGH UPLAND, AND HILL AREAS

The soils of this group in the province are the most affected by erosion, owing to the fact that their surface relief varies from undulating to rolling to strongly rolling, and hilly. Erosion on these soils has been from moderate to serious to severe and excessive. About 1/4 to all the surface soil and over 3/4 of the subsoils have been eroded and with frequent gullies. In some sections, all the original surface soil and subsoil have been washed away exposing the bedrock beneath. Included in this group are the soils of the Jasaan, Lourdes, Bolinao, Faraon, Camiguin, and Alimodian series comprising a total area of approximately 199,890 hectares, or 51.45 per cent, of the total area of the province.

Erosion on Jasaan clay. — Erosiveness of the Jasaan clay varies considerably due to the differences in topography, system of farming, and management of the soil. The plateau or the nearly flat upland with the highest slopes ranging from 5 to 7 per cent in Claveria and Cagayan de Oro City has slight to moderate sheet erosion. About 1/4 to less than 1/2 of the original surface soil has been eroded. The erosion has been primarily due to faulty system of farming and management of the soil. This soil has a normal surface soil depth of 35 centimeters and about 27 centimeters has been left in the less eroded cultivated areas and about 20 centimeters in the moderately eroded cultivated areas.

In Claveria, the area cultivated is mostly devoted to the grain type of farming using upland rice and corn. In some portions, root crops such as onions, camote and cassava are planted and in other sections abaca is grown. The cultivation is mostly up and down the slopes resulting to moderate sheet erosion with some shallow gullies. Accordingly, the production in this area has decreased due to the effect of erosion losses of the surface soil and the neglect of using commercial fertilizer in the fields. In the past years the farmers produced as high as 85 cavans of palay per hectare in this area. The highest they can get now is about 65 cavans of palay to the hectare. This area should be under good farming system practices such as crop rotation, contour cultivation, terracing, and the use of commercial fertilizer to improve the fertility and conserve the soil and the water for the crops.

The area in Gingoog is either planted to coconut and abaca, or under secondary forest and is moderately eroded. About 1/4

to 1/2 of the surface soil has been eroded while that found in Cagayan de Oro City is cogonal and has 1/4 of the surface soil eroded. The areas located in Jasaan and Claveria are severely eroded with frequent deep gullies. They have lost over 3/4 of the original surface soil to about 1/4 of the subsoil. Many of these areas are sparsely vegetated.

The greatest contributing factor to erosion on these areas is the slope of the land. Not only is the land more rolling but also is hilly with steep slopes. Coupled with the scarcity of trees, erosion has became severe. Any erosion control program on these areas revolves into a good reforestation program. Those scattered areas being cultivated under kaiñgin system should be planted to permanent trees.

Erosion on Jasaan clay, stony phase. — Slopes on the Jasaan clay, stony phase, vary from 3 per cent to 80 per cent or more. But there are small scattered areas between Cagayan de Oro City and Lumbia along the provincial road to Bukidnon that are nearly flat with the highest slopes of about 4 per cent. Practically these areas are not cultivated owing to the presence of plenty of stones, boulders, and outcrops on the surface that hazards cultivation. However, due to the relief of the land and the heavy texture of the soil which prevents the rapid percolation of water through it, there have been excessive surface wash taking off rapidly the surface soil and at the same time affecting the vegetation.

Erosion on the nearly level areas is moderate with about 1/4 of the original surface soil already eroded. The strongly rolling and hilly areas on the other hand, have 1/4 to more than 3/4 of the surface soil and 1/4 or more of the subsoil lost through erosion. Frequent deep gullies are distinct and they can be seen at a distance. The removal of the original surface soil has left infertile subsoil. Consequently, even the vegetation in this soil phase is very poor. It is covered by thin cogon, shrubs, and few trees.

Erosion control on this soil should stress more emphasis on the vegetation. Since practically the area of this soil phase is not cultivated it should be reforested in order that more trees would cover the area. Burning of the cogon should be prevented because this practice deprives the soil of its cover and leads to or induces the erosion and gullying.

Erosion on Jasaan clay loam. — The greater part of this soil is strongly rolling and hilly with slopes varying from 8 to 70 per cent or more. It occupies the area from Lumbia to the border of Lanao and Bukidnon along the Cagayan River. About 10 to 20 per cent of the area is under thick forest and has normal erosion. Kaiñgin system of cultivation has steadily thinned the forest area and from it thrives cogon and secondary forest. As a result between 1/2 and 3/4 of the original surface soil has been lost through erosion. There are small areas which are nearly level and these are slightly eroded.

The important factor causing erosion on the Jasaan clay loam is the nature of vegetation, hence erosion control should depend to a considerable extent on good vegetative cover. Kaiñgin system of farming in this soil should be stopped to prevent the destruction of the forest area and to minimize erosion losses. Since a greater portion of the area is under secondary forest and cogon, these kinds of vegetation should not be injured in order that they could grow thicker to cover the surface soil and to effectively reduce excessive run-off and too much erosion. If and when, however, the area is cultivated only the lower slopes should be tilled using crop rotation, contour cultivation and terracing.

Erosion on Bolinao-Jasaan complex. — This soil complex occupies the hills east and west of Jasaan, and has from 5 to 90 per cent slope or more. About 50 per cent of it is planted permanently to coconut and bananas. A small portion is under kaiñgin and the rest is secondary forest.

Erosion on this soil complex has been serious and about 1/2 to over 3/4 of the original surface soil has been eroded. It is possible that in the past this soil had been under kaiñgin system of farming and later on, one-half of it has been planted to coconut and the rest become secondary forest, thus erosion has been serious. Due to the slope of the land, coupled with the heavy texture of the soil which is heavy clay and of poor permeability, very little water seeps into the ground causing run-off to become excessive.

To control erosion on this soil complex is to plant cover crop especially legumes on the coconut field. This cover crop prevents the excessive flow of surface water. It also improves soil fertility and permeability. The secondary forest should not be cut off nor burned.

Erosion on Lourdes clay loam. — The relief of this soil ranges from rolling to hilly and mountainous. Slopes vary from 8 per cent to 100 per cent and over with excessive run-off allowing considerable variation in the degrees of erosion. Thus in some portions of the area where the slope is from 8 to 25 per cent and are cogonal have a moderate sheet erosion. About 1/4 to 1/2 of the original surface soil has been washed off. Where the area had been tilled over 1/2 of the original surface soil has been eroded. The areas having slopes of over 25 per cent to 50 per cent occupying the region south of Lourdes proper to Mts. Taguslit, Tuagon, and Nagalangan, have been seriously eroded and 3/4 or over 3/4 of the original surface soil has been washed away. Areas with over 50 per cent slopes have been severely eroded with deep gullies. In some places almost the whole original surface soil has been removed through surface wash and in the other places 1/4 or more of the subsoil has been eroded. The area occupied by primary forest is about 20 per cent of the total area of this soil and has normal erosion.

Erosion losses in this soil are due undoubtedly to the topography of the land and the fact that the areas are generally bared of forest. The sparse vegetation is a mixture of cogon and other grasses, and shrubs which could not prevent the rapid flow of surface water. Although the farming practices are improper, they cause insignificant erosion in the area because a very little hectarage of this soil is farmed in contrast to the untilled areas. Besides, most of the areas cultivated are the valleys and the level portions.

Any program of erosion control on the Lourdes clay loam resolves itself on reforestation as most of the land is uncultivated. The tilled rolling areas should be under a good rotation system of farming such as terracing, contour farming, and strip cropping. These farming practices should also be followed when more of the undulating area become cultivated. Grazing is suited for this land. Application of lime and commercial fertilizer is important practice in farming and should be resorted to in this soil so that any combination of farm crops can be grown and good pastures can be fairly easily established on the farm.

Erosion on Bolinao clay. — The Bolinao clay practically occupies the whole of Alubijid and El Salvador. A bigger portion of Initao, a part of Cagayan de Oro City, and Lumbia bordering Bukidnon Province also belong to this soil type. It has a heavy clay soil with a poor permeability. The relief is nearly flat upland, undulating, rolling and hilly. The slopes vary from 5 per cent to as high as 80 per cent on the more rolling and hilly areas. Surface drainage is excessive but the internal drainage is poor. About 20 per cent of the area is cultivated, 80 per cent of which is mostly in coconut. The vegetation of the uncultivated areas is a mixture of cogon, grass, and secondary forest. Some of the hill areas and steep slopes are planted to Ipil-ipil.

Erosion on the Bolinao clay is moderate to serious and severe. On the cultivated fields, because of topography and management about 3/4 to over 3/4 of the original surface soil and about 1/4 of the subsoil have been washed off. Slopes of even greater than 25 per cent are cultivated to grain crops and the presence of a heavy subsoil allows the downward movement of water very slowly. Consequently, excessive run-off has been causing a rapid washing away of the surface soil. In some sections of the area, the parent material of limestone rock is exposed on the surface. In many places are scattered limestone gravels, stones, and boulders in abundance on the surface as a result of erosion. In the uncultivated areas, the extent of erosion shows that 1/4 to 1/2 and over of the original surface soil has been eroded in the lower slopes. On the more rolling and hilly areas 3/4 and over of the original surface soil and 1/4 or over of the subsoil have been removed as a result of erosion. The parent rock in some places of the uncultivated area is exposed as outcrop on the surface.

The important factors causing erosion on Bolinao clay are slopes of the land and the management. The cultivated areas are under clean-tilled cropping systems using grain crops, a farming practice that induces erosion. To prevent erosion on the cultivated areas of Bolinao clay is to plan a good farming practice based on the relief. A good rotation system of farming, contour farming, and strip cropping are most important. Because of the seriousness of erosion there is very little surface soil left and terracing seems not practicable. Only the lower slopes should be devoted to grain farming using good management practices. The rolling areas where erosion is serious farming should be confined to the ridge tops and should be under strip cropping, contour farming and crop rotation. Where gullying is serious as to make farming more difficult, it is desirable that such fields should be planted to trees as to prevent further gullying. The uncultivated

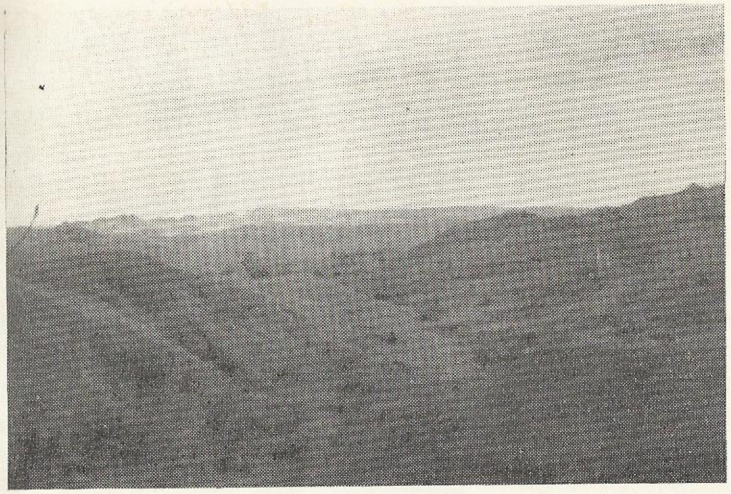

Fig. 29.—Area of Bolinao clay. The foreground is severely eroded, while the background is moderately to seriously eroded.

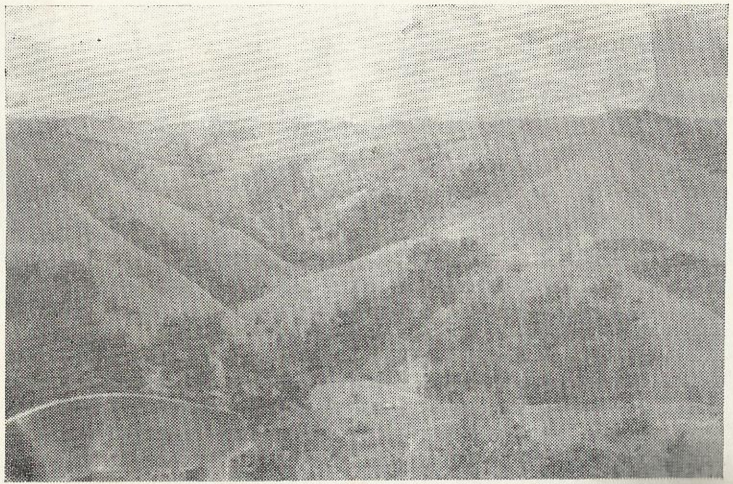

Fig. 30.—Mountain soils undifferentiated showing area excessively eroded.

areas should be under tree cover. Ipil-ipil is a kind of a tree-legume that is most adapted to this soil. Where this plant is grown as it has been grown in many areas, it has a good growth and grows fast. When this crop is planted in the uncultivated areas, it could easily give a good cover to control erosion.

Erosion on Faraon clay. — The Faraon clay, like the Bolinao clay, is rolling and hilly with slopes varying from 5 per cent to 80 per cent or more. It occupies the rolling and hilly areas of Manticao along the shore to the boundary of Lanao, and also the western part of Initao. The rolling and hilly areas along the coast are planted to coconut. In some places, corn, upland rice, and camote are raised.

Erosion on the Faraon clay varies from moderate to serious erosion. About 1/4 of the original surface soil to all of it and 1/4 of the subsoil of the more rolling and steep slopes have been eroded. Gullies in this soil are also numerous. Some are shallow and others are wide and deep. The nature of the relief, and partly the management practice including the vegetation are the important factors that contributed erosion in this soil.

The erosion controls suggested for Bolinao clay hold equally well with this soil. Both have practically the same relief, management practices, extent of erosion, physical characteristics of the soil and parent materials.

Erosion on Camiguin clay. — Camiguin clay is well distributed in Camiguin Island and the eastern part of the province. The relief is rolling to hilly and mountainous, and the slopes vary from 5 per cent to 100 per cent or more. The elevation is from 300 to 3,000 feet above sea level. The surface drainage is good to excessive but the internal drainage is fair owing to the nature of relief and the heaviness of the soil. The surface soil reaching to about 70 centimeters deep is compact clay, sticky, and of poor permeability.

Erosion on this soil like the other upland soils of the province has been moderate to serious and severe. This is especially true on areas cultivated or sparsely vegetated. The more undulating areas have moderate erosion and about 1/4 to 1/2 of the original surface soil has been lost because of sheet erosion, and gullying has been occasional. The more rolling areas has suffered serious sheet erosion and about 3/4 or more of the original surface soil has washed away. The hilly areas which are not covered with forest nor planted to coconut have been severely eroded, having 3/4 or all of the original surface soil and about 1/4 of the subsoil had been removed by surface wash. The higher hills and mountains are thickly forested and have a normal erosion.

The contributing factors to erosion on the Camiguin clay are the slope, vegetation, and farming management. Most of the rolling and hilly areas along the coast are planted to coconut permanently, and presently erosion on these lands is moderate. They need cover crop to reduce run-off and minimize erosion. However, the rolling areas which is under clean-tilled cropping system has been seriously to severely eroded. Crop rotation and planting of cover crop should be practiced in the more rolling areas. Grain farming should be allowed only in the lower slopes with good rotation, contour tillage, terracing and fertilizing practices. The open lands if necessary should have their vegetation kept intact and burning or the kaiñgin system of farming should be stopped to have a surface protection of the soil and minimize erosion losses.

Erosion on Alimodian clay loam. — Slopes on the Alimodian clay loam vary from 2 to 50 per cent or more. The lower slopes have an average of 10 per cent. This soil is moderately eroded. In some cases about 1/4 to less than 1/2 of the original surface soil has been lost through surface wash, and in some areas 1/2 to less than 3/4 of the original surface soil has been eroded. In the higher slopes about 3/4 of the surface soil has been washed away. In these areas, shallow gullying has been moderate. The higher hills are either secondary forest or primary forest.

Most of the cultivated portions of this soils are the undulating areas averaging 10 per cent slope and are mostly planted to coconut. Grain-type of farming is generally on the lower slopes, although some areas on the higher slopes are kept under clean cultivation. Most of the rolling areas are cogonal and secondary forests.

To control erosion on the cultivated areas under clean culture, it is essential to use a more suitable rotation system of farming, with contour cultivation and fertilization. The areas planted to permanent crop should be grown to soil-building legumes as cover crop. However, because the soil is friable, terracing seems not feasible. Where the slopes are rather steep, trees should be grown and should be protected from fire and kaiñgin.

3. Erosion on the Miscellaneous Land Type

Most of the miscellaneous land types, except some areas of the mountain soils undifferentiated which are bared of vegetation have no apparent erosion or are in normal erosion. This is because most of them are either nearly flat land or in primary forests.

Hydrosol.—Hydrosol is one of the miscellaneous land types. It is nearly level and is underwater most of the year. It is located usually near the mouth of the rivers, and in some protected bays along the shore. Nipa palms and various species of mangrove are grown in the hydrosol. Some areas of the hydrosol are made into fish ponds for the culture of fish, and some areas are made into salt beds where salts are manufactured.

Erosion on the hydrosol is not apparent. On the other hand, because of its location, it receives soil materials from the uplands and higher adjacent lands.

Beach sand.—The beach sand occurs along the coast. This land type is generally level and have no apparent sheet erosion. However, when the sea waves are strong, they may either carry some of the beach sand into the sea or deposit some stones and sandy materials.

Mountain soils undifferentiated.—This land consists of some plains, rolling areas, high hills, and mountains ranges which are thickly vegetated. Most of the high hills and mountain ranges bordering Lanao, Bukidnon, and Agusan Provinces belong to this land type. They are generally under normal erosion owing to the thick vegetal covering. Nevertheless, there are areas in the lower slopes where the forest cover was cut, perhaps as a result of kaiñgin, and erosion has taken its toll. Some of these areas are at present severely eroded. Other places are excessively eroded. These seriously and excessively eroded areas, should be planted to trees for protection against soil erosion.

Effects of Soil Erosion

Erosion in the Philippines has become a national problem. Mamisao (43) pointed out that of the 11,637,068 hectares of open land and cultivated land of the Philippines, 3,948,576 hectares are subject to severe erosion and 4,947,374 hectares are subject to all stages of erosion, or a total area of 8,895,948 hectares, which is 29.9 per cent of the total area of the Philippines and 76.5 per cent of agricultural area of the country.

In Misamis Oriental there are 27,714 hectares or 7.07 per cent of the total area of the province that have no apparent erosion including 7,833 hectares, or 2 per cent, of beach sand and hydrosol that are non-agricultural lands. As matters stand, only 19,881 hectares or 5.07 per cent of the land of the province are good agricultural lands against 234,059 hectares or 59.76 per cent that are subject to different stages of erosion. Moreover, the bulk of the good quality cropland is steadily losing its fertility under prevailing methods of management.

Considering that the population of the province is 369,671 (1948 census) there is 1 hectare of good land for every 18 persons not enough to support a decent living. Even if the 234,059 hectares that are subject to different degrees of erosion are included, still there would be less than a hectare for every man, woman, and child and this area could not give a modest living standard. Unless the soils of the province are properly safeguarded, the province will ultimately face a serious threat of land shortage.

Furthermore, erosion is a threat to future security. Mamisao (7) again pointed out that 67,000 kilograms is the average amount of top soil washed off from each hectare of land in the Philippines carrying with it an equivalent amount of nutrient elements as follows:

N ...... 50 tons of ammonium sulfate
P_2O_5 ..... 75 tons of superphosphate
K_2O ..... 23 tons of potassium sulphate

Based on the number of hectares affected by erosion in the province, the loss of soil fertility is enormous. The use of commercial fertilizers may help to relieve the farmers but there is the monetary consideration and the fact that unless the management practices are corrected the fertilizers applied are of no consequence as these will ultimately be washed off by run-off.

Soil erosion also affects the good lowlands by depositions of not only fertile alluvial materials from the uplands, but also infertile subsoil, sands, gravels, stones, pebbles, and sometimes boulders rendering the lands unsuitable for cultivation. It also destroys standing crops from these lands as a result of depositions. Furthermore, because of erosion and silting there are rivers and irrigation canals that become of no value to agriculture. River bottoms as a result of silting become high, and as lands in the upper section are cut by erosion, floods grow more violent causing rivers to change their courses destroying large areas of agricultural land in their paths.

Soil erosion has also attendant economic consequences. The cost of soil conservation in building up the lands affected by erosion is tremendous and in some cases the money and efforts used are not worth the rehabilitation made. While it is true that erosion on certain farms is hardly detected and appears slowly, the steady loss of topsoils is felt when crop yields decrease. Formation of gullies and the exposure of heavy subsoil make the land more difficult to till. Eroded soils require more fertilizers and more water for profitable crop yields. It reduces the farmers' income and the families' living standard. Farming becomes more difficult, more costly, and less beneficial. To the individual farmer the result is bad, but it is tragic to the country, taking the farming community as a whole because erosion undermines the social and economic life of the entire nation. A truly sound and lasting national prosperity and peace cannot be attained if the soils are not conserved.

CONTROL OF SOIL EROSION

Bennett (20), stated that "since the dawn of time, soils have been on the move. Rain and wind have scoured away almost constantly at the earth's surface and transported soil particles from place to place. But under a protective cover of grass, trees, or other thick-growing vegetations, the rate of soil removal has always been exceedingly slow-no faster, generally, than the normal rate of soil creation. This favorable soil balance prevailing under natural conditions was disturbed almost from the moment when men first started to till the earth for food."

Removal of soils by rain in the Philippines have been steadily going on since the beginning of our agriculture. While there have been some individual farmers who have noticed this happening and have tried to remedy it by using their own treatment, many have tolerated the destruction of their farms, maybe because they may not have been aware that erosion has been steadily removing tons of the topsoils off from their farms. Erosion in many cases is too often overlooked, because its inception is hardly noticeable. It removes tons of the surface soil from a farm without leaving any detectable clue of the loss unless examined carefully.

Erosion control practices are profitable. They save soils for the generations to come, and also increase the yields of crops. The rice terraces in Mountain Province have been producing good rice crops for many years, and have been handed down to unnumbered generations. Whether the Ifugaos have been conscious of the problems and remedies for erosion or that they were constrained to construct the terraces due mainly to the influence of environmental condition, one can never tell. The fact remains however, that whatever their reasons were, it is clear that the terraces have saved the hill sides from damage caused by erosion.

The effective approach to the control of erosion is through a well planned soil conservation system. Since "soil erosion is the result of man's failure to adapt his culture to natural limitation upon land use," the adoption of a farming system appropriate to the land's specific needs and adaptibility for use, gives a feasible solution of the problem of soil erosion. Wrong use of the land has been too frequent. The cultivation of areas that have over 25 per cent slope under clean-tilled cropping system, and on the severely eroded areas or on steep or hilly relief are examples of the misuse of lands. The cultivated lands planted to crops at present are not all adapted to them according to permanent land use. Each soil type or phase has its own characteristic and capability for crop production and its misuse would cause and accelerate erosion.

Soil conservation is patterned on the premise of land use adaptability. The land is cultivated in its known fitness to physical bounds so that it is managed with suitable measures for erosion control. While soil conservation offers the best means of controlling erosion, its use in the Philippines however, has not yet gained a proper place in the agricultural pattern. In the United States as a result of the work of the Soil Conservation Service, soil conservation measures have been adapted through a planned system of land use and has very largely controlled erosion in numerous areas of the country.

Essentially, soil conservation control of soil erosion involves a combination and a systematic use of different control patterns fitted to the "peculiar needs and adaptability of the various kinds of land requiring protection." Mechanical and vegetative methods of erosion control are important patterns in the scheme of soil conservation. Used individually or in combination and properly coordinated, they are the best measures

against erosion. On the other hand, when used improperly the benefits derived is less than the harm they give.

Vegetative methods of erosion control advances the idea that the soil have adequate vegetative protective covers. Adequate vegetative cover is a combination of good farming practices. It protects the soil from erosion losses, and it helps to maintain or improve soil fertility besides increasing the yields of crop per unit area. Some of the vegetative control measures are strip cropping, cover cropping, crop rotation, close-growing crops, retirement of severely eroded cultivated land to the permanent protection to grass and trees, and planting farm woodlots and wind breaks. Mechanical methods on the other hand includes artificial structure, likes dams, terraces, and diversion ditches. Contouring, ridging, subsoiling, etc, are also classified under mechanical measures. These methods of erosion control are based on land-use capability, thereby necessitating land-use planning survey to classify the land within a use capability group in order to determine which of the land classes need the intensive practices required to conserve soil and moisture and maintain productivity. Accordingly, there are four classes of crop-land use capability, and each class, depending on the degree of slope based on land-use erosion, requires a certain number of practices for the control of erosion. In general, vegetation furnishes the best surface protection, but when supplemented by the mechanical measures become more effective and economical in the control of erosion.

Coincident with the control of soil erosion is the collective cooperation of the Government and the individual farmers. Cooperation is essential to get effective results. Incidentally, the farmers should be informed or educated in the adoption of sound land-use principles and practices and unless the people, particularly the farming community are not acquainted with the causes of erosion, its effects, and methods of control, the problem of soil erosion control can not satisfactorily be solved. It is imperative that the people should learn and appreciate the importance of soil, "that it is the basic natural resource of the farming industry; that the soil is the source of all the farmer's income; that any investment of capital or labor which the farmer places in his soil, to build up and preserve the fertility, makes his equity in the land that much more valuable; and that effective erosion control requires a knowledge of and an interest in good farming practices." Any program of erosion control lacking educational background, is a sure failure when the respective control measures are adopted by the farmer. This service to education and direct aid to farmers can be carried out in actual field demonstrations of the accepted practices in soil conservation farming with the close cooperation of the different agencies concerned with agriculture in this country.

CHEMICAL CHARACTERISTICS AND FERTILIZER REQUIREMENTS OF THE SOILS OF MISAMIS ORIENTAL PROVINCE

By R. T. Marfori, I. E. Villanueva, and G. C. Bandong [1]

An understanding of the chemical nature of soils is fundamental in the promotion of scientific agriculture. It is therefore necessary that the soils of Misamis Oriental be studied and classified based on the morphologic and genetic characteristics found in the fields supplemented by the chemical investigations and interpretation of the results of analysis of the soil samples brought to the laboratory. The results obtained from the chemical investigations aid in adapting and formulating a systematic and proper soil management for an efficient cropping practice.

The chemical studies reveal the following: (a) soil reaction (or pH value) which serves as a guide to crop adaptation of the soil type by denoting acidity or alkalinity and vice versa; (b) quantity of the nutrient elements needed for plant growth as to deficiency or sufficiency; (c) presence and quantity of toxic substances, and (d) fertilizer and lime requirements of the soil type for a maximum crop yield.

Plant nutrient elements needed in greater proportions are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and iron, while those needed in lesser amounts to the extent of only 1/4 part per million in a soil solution are boron, copper, manganese, zinc, cobalt and molybdenum. These latter six elements are technically designated as trace elements because they are needed in small amounts by plants. They are also essential to plant nutrition. When present in big quantities, they give toxic effects to plants. Their absence or deficiency in the soil, however, causes necrotic symptoms. Carbon, hydrogen, and oxygen are derived from the air while the other elements come from the soil. As a result of the deficiency of any or several of these above-mentioned elements, crop yields are reduced.

[1] Soil Scientist and Chief, Division of Soil Laboratories, Soil Chemist and Jr. Soil Chemist, respectively.

The essential nutrients may run short in the soil due to cropping, leaching and erosion. Nitrogen, phosphorus and potassium are the major nutrients that are always easily depleted in the soil. As a result, deficiencies of such elements are likely to occur in any soil type and unless they are corrected, normal growth of plants would not be possible. Applications of manures and commercial fertilizers are necessary to replenish the supply or to replace what the crops removed from the soil. Nitrogen deficiency may be corrected by the addition of animal and green manures or commercial nitrogenous fertilizers such as ammonium sulfate and sodium nitrate. Superphosphate, guano and other phosphatic fertilizers will check phosphorus deficiency. The application of wood ashes or commercial potassic fertilizers such as muriate of potash and potassium sulfate will also solve the potash problems of soils. Calcium and magnesium are minor or secondary nutrient elements which may occasionally be present in insufficient amounts. The calcium deficiency, however, may be corrected by the addition of lime or dolomitic limestone to the soil; it not only supplies calcium ions needed by plants, but also corrects the acidity of the soil, thereby, preventing the occurrence of an unusual and excessive acid reaction.

METHODS OF CHEMICAL ANALYSIS

Crop response to fertilizers applied in the soil is correlated to the determination of readily available nutrient elements. This determination also serves as an index of the fertility of the soil. It is only for nitrogen where total analysis was employed because this element, in the presence of proper microorganisms and under favorable conditions, is easily convertible into forms available for plant assimilation.

Calibration of the rapid chemical methods under Philippine conditions with the results of liming and fertilizer experiments conducted both in the field and in spots in the greenhouse is being conducted up to the present time by the Division of Soil Laboratories. For lack of comprehensive data from local experiments, the results obtained abroad are then cited.

In the preparation of samples for chemical analysis or tests, the surface soil samples were first air-dried, pulverized with a wooden mallet, passed through a 2-mm. sieve, and then thoroughly mixed.

A Beckman model H-2 pH meter fitted with glass electrode was used for determining soil reaction or hydrogen ion concentration in the soil. The organic matter was determined by following the Walkley-Black Method (71).

The total nitrogen content of the soil was determined according to the "Methods of Analysis" of the Association of Official Agricultural Chemists of the United States (18). The methods of Spurway (63) were followed in the determination of ammonia and nitrates. Readily available phosphorus was determined by the method of Truog (67). Available potassium, calcium, magnesium, iron and manganese were determined according to the methods of Peech and English (56). A Leitz photoelectric colorimeter provided with suitable light filters was used in the colorimetric determination of available constituents.

INTERPRETATION OF CHEMICAL TESTS

Soil reaction or pH value.—Soil reaction or pH value is one of the outstanding physiological characteristics of the soil, and since microorganisms and higher plants respond so markedly to their chemical environment, its importance has long been recognized. It denotes the degree of acidity or alkalinity of the soil and it is expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, lower value indicates acidity, and higher value indicates alkalinity. The behavior and availability of plant nutrient elements as well as those of toxic substances is affected by it. As such, it becomes a limiting factor for plant growth and reproduction. Soils with a high degree of acidity or those with very low pH values have soluble aluminum in such a concentration as to be toxic to plants. Aluminum is rendered very soluble at very low pH values. On the other hand, soils with very high alkalinity or those with very high pH values render the iron, manganese, copper, and zinc in an unavailable form to plants thereby causing the plants to exhibit malnutrition or abnormal growth.

Truog (68) recently published a modified version of Pettinger's chart showing the general trend of the relation of soil reaction to the availability of plant nutrient elements. This is reproduced here with Truog's accompanying explanation.

"In this chart, reaction is expressed in terms of the pH scale. The change in intensity of acidity and alkalinity from

Table 14 Chemical analysis of the different soil types of Misamis Oriental arranged according to the decreasing productivity ratings for corn.

	Crop Productivity ratings							Available constituents in parts per million (p.p.m.)								
	Corn 100=17 cavans/ Ha.	Coconut 100=3750 nuts per Ha.	Rice: Lowland 100=60 cavans/ Ha.	Rice: Upland 100=20 cavans/ Ha.	pH value	Organic matter %	Total nitrogen	Ammonia (NH_3)	Nitrates (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe)
...usaan clay	85	95	—	200	5.45	7.82	0.27	10	5	4	168	500	300	390	3
...umbajao clay	80	110	80	100	5.50	6.60	0.23	10	2	12	289	900	210	188	1
...usaan clay loam	80	95	—	200	5.90	6.73	0.24	10	25	6	166	1400	300	132	trace
...an Manuel loam	75	110	85	—	5.80	3.97	0.15	2	10	73	225	2700	470	19	3
...mingan (clay)/loam	75	110	85	—	6.10	4.47	0.17	10	5	194	113	2800	610	49	1
...nting clay	75	100	85	—	6.40	3.95	0.15	10	trace	44	239	3700	3070	53	1
...tima clay	75	110	80	—	6.40	5.61	0.18	10	25	45	147	3500	2420	47	1
...mingan clay loam	70	95	85	—	5.80	3.90	0.18	10	10	7	96	3100	390	139	1
...limodian clay loam	50	95	—	60	6.20	4.24	0.12	10	trace	90	68	2600	210	33	trace
...olinao clay	50	105	—	75	6.40	4.14	0.20	10	10	3	93	17800	1940	trace	1
...aranon clay	50	105	—	75	6.75	4.37	0.22	10	10	12	185	25600	4890	4	trace
...ourdes clay loam	50	80	—	50	5.80	4.78	0.12	2	trace	6	162	4000	1060	20	1
...miguin clay	45	100	—	—	5.70	5.72	0.18	10	trace	28	295	1900	210	25	3
...usaan-Bolinao complex	45	95	—	60	5.90	3.92	0.15	10	trace	24	193	4300	780	73	1
...usaan clay, stony phase	45	75	—	—	5.80	13.10	0.33	10	trace	52	150	2000	260	4	trace

one pH value to another is shown graphically in the diagram by the change in width of the heavily cross-hatched area between the curved lines.

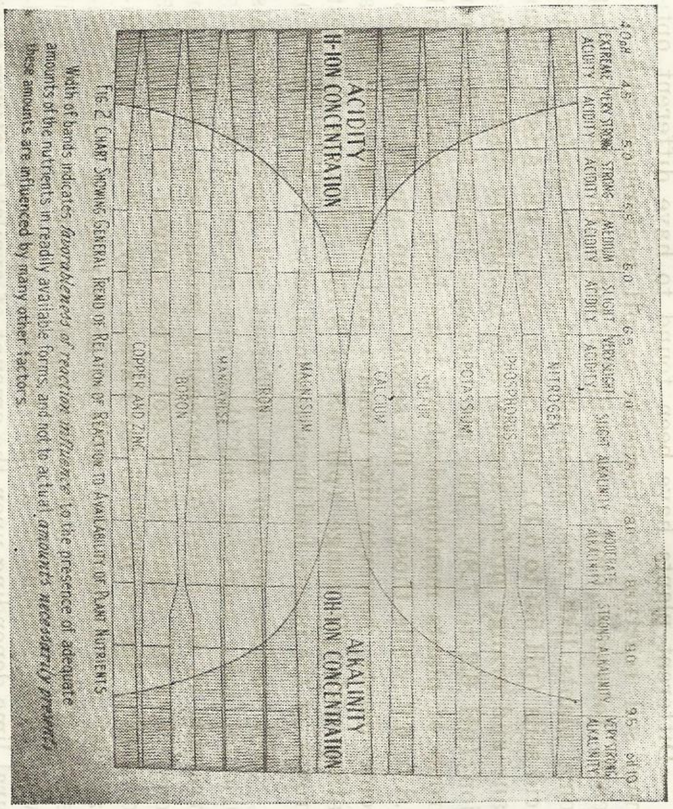

Fig. 31.—Width of bands indicates "favorableness of reaction influence" to the presence of adequate "amounts necessarily present"; these amounts are influenced by many other factors.

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 in this range a satisfactory supply of available 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 supply in available form. Other factors than reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply."

Different plants have been found to have different optimum soil reaction requirements or pH preferences and different tolerance limits. It will be noted in table 14 that some plants like rice, pineapple and tobacco prefer medium acid soils (pH 5.5 to 6.1), while other species like alfalfa, sugar cane and orange prefer slightly acid to slightly alkaline reaction (pH 6.2 to 7.8). The pH tolerance limits for the first group of plants mentioned above have been estimated at pH 4.8 to 6.9, while those for the second group are pH 5.5 to 8.5. Some plants, however like tomato and corn can tolerate a rather wide pH range (pH 4.8 to 8.15), although the best growth of the plants had been obtained between pH 6.2 and 7.0.

The surface soils of the different soil types of Misamis Oriental were analyzed and they are presented in table 15 arranged in the order of decreasing productivity ratings for corn. The pH values of the soil types ranged from pH 5.45 for Jasaan clay to pH 6.75 for Faraon clay. Except for Bolinao clay and Faraon clay with an accompanying calcium content of 17,800 p.p.m. and 25,600 p.p.m respectively, all the soil types would respond to a light to heavy application of agricultural lime depending upon the amount of available calcium they contain. Jasaan clay and Mambajao clay which have relatively low calcium contents accompanied by lower pH values than the other soil types would probably give better response to liming application than Lourdes clay loam and Jasaan-Bolinao complex which have about eight times as much of available calcium and higher pH values.

Nitrogen.—Nitrogen makes up 2 to 4 per cent of the dry weight of plants. It is essential to new cell formation and is a basic part of proteins and of chlorophyll, the green coloring matter of plants. It is used largely in the development of fruit, grains and seeds. Stimulation of plant growth and hastening of maturity may be due to an ample supply of available nitrogen in the soil. However, an excessive supply may tend to cause not only excessive growth but also other adverse effects such as: (1) lodging in small grain crops like rice, oat, barley, etc.; (2) susceptibility to plant diseases; (3) lowering of the purity of cane juice in sugar cane; and, (4) decreased tensile

strength of bast fibers in fiber plants. Where succulence is considered good quality for certain crops like leafy vegetables and forage grasses, an abundance of nitrogen in the soil is highly desirable.

The sources of nitrogen in arable soils is derived from green manures, farm manures, crop residues, commercial fertilizers and from rain. Certain microorganisms also fix atmospheric nitrogen for the use of plants. Nitrification, which is brought about by the action of specific soil microorganisms, converts the nitrogen of nitrogenous organic matter in three stages,

TABLE 15. *The pH requirements of some economic plants*

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

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 textiles Nee* [1]	Y	X	X	X	Y	O
Caimito, *chrysophyllum caimito Linn* [1]	Y	X	X	Y	O	O
Coffee, *coffea arabica Linn* [1]	Y	X	X	Y	O	O
Cowpea, *Vigna sinensis* (Linn.) Savi [2]	Y	Y	X	Y	Y	—
Corn, *Zea mays* Linn. [2]	Y	Y	X	X	Y	Y
Durian, *Durio zibethinus Linn* [1]	Y	X	X	Y	O	O
Peanut, *Arachis hypogaea* Linn [2]	Y	Y	X	X	Y	—
Pe-tsai [4] *Brassica pekinensis* Rupr [4]	Y	Y	X	X	X	X
Rice, *Oryza sativa* Linn [1]	Y	X	X	Y	Y	O
Sugar cane, *Saccharum Officinarum* Linn [2]	O	Y	X	X	X	Y
Tobacco, *Nicotiana tabacum* Linn [2]	Y	X	Y	O	O	O
Sweet potato, *Ipomoea batatas* (Linn.) Poir [1]	Y	X	X	Y	O	O
Cassava, *Manibot esculenta* Crantz.	Y	X	X	X	Y	Y
Pineapple, *Anonas comosus* (Linn.) Merr [1]	Y	X	Y	O	O	O
Banana, *Musa sapientum* Linn. [1]	Y	X	X	X	Y	O
Tomato, *Lycopersicum esculentum* Mill [2]	Y	Y	X	X	Y	Y
Onion, *Allium cepa* Linn [2]	O	Y	X	Y	Y	Y
Soybean, *Glycine max* (Linn.) Merr [2]	Y	X	X	X	Y	Y
Orange, *Citrus aurentium* Linn. [3]	—	Y	X	X	X	Y

[1] Based from the soil reactions where they are grown with the productivity ratings of the soil types in 11 provinces. A pH ranges of 5.7 to 6.2 was found to be most suitable for the growth of upland rice, variety Inintiw, by Rola, Nena A., and N. L. Gavlez. 1949. Effects of soil reaction on the growth of upland rice and on its nitrogen, calcium, phosphorus and iron content. Philippine Agriculturist 33: 120-125.

[2] Data taken mostly from Weir Wilbert Weir. 1936. Soil Science. Its principles and practice. J. B. Lippincott C. Chicago and Philadelphia.

[3] From Spurway, G. H. 1941. Soil reaction (pH) preferences of plants. Mich. Agr. Expt. Sta. Sp. Bull. 306. Optimum range given was pH 6.0-7.5.

[4] From Areiaga, Antonio N., and N. L. Galvez. 1948. The effect of soil reaction on the growth of pet-sai plants and on their nitrogen, calcium and phosphorus content. Philippine Agriculturist 32: 55-59. Normal growth reported was in pH 4.2 to 8.6; optimum range was pH 5.8-8.6.

namely; its conversion first into ammonia, then into nitrites, and finally, into nitrates. Production of nitrates through nitrification is brought about by certain soil conditions as (1) good aeration; (b) optimum temperature of 80-90° F; (c) proper moisture; (d) proper microorganisms; and, (e) sufficient supply of nitrogenous organic matter.

While most plants assimilate nitrogen as nitrates, rice and other members of the grass family absorb it in the ammoniacal form. In the ammoniacal form, nitrogen can be fixed in the soil and it is therefore not easily lost through leaching. On the other hand, nitrates can't be fixed so they are easily lost through leaching. If commercial fertilizer is to be used, its cost and the amount of application will decide on the choice of the nitrogen carrier for the crops to be grown. Where immediate effect is desired as for short season crops like vegetables, nitrates are preferable to ammoniacal nitrogen. Nitrates in combination with sodium or calcium tend to reduce soil acidity, but ammoniacals generally increase soil acidity. But, for long season crops like sugar cane and irrigated crops like rice, ammoniacal nitrogen is preferable to apply than nitrates for efficiency and lower cost.

Spurway, in his method of determining ammonia and nitrates, found that 2-5 parts per million (p.p.m.) in soil are considered low, 10-25 p.p.m. as medium or normal supply and 100 p.p.m. or more as very high or excessive. Low values for nitrates accompanied by a medium or normal supply of ammonia are normal for soils where nitrification proceeds to completion, or where the ammonia is immediately converted into nitrites and then to nitrates. Low tests may also mean that the ammonia is used up by plants as fast as formed, or that it is fixed in the base exchange complex of the soil, or lost through leaching. When the soil has a high content of decaying organic matter or when it has been recently fertilized with ammoniacal compounds, a comparatively high test for ammonia will be obtained as expected. The test for the various forms of nitrogen are not very specific unlike that for phosphorus and potassium. The results of the three nitrogen tests have to be interpreted together to be of some diagnostic value. High ammonia with low nitrate test indicates that some unfavorable soil conditions are interfering with nitrate formation.

Philippine cultivated soils have been analyzed for total nitrogen in this laboratory and it was found that the average total nitrogen content was 0.14 per cent. With this as basis it can be seen from table 14 that of the fifteen soil types identified in Misamis Oriental, only Alimodian clay loam and Lourdes clay loam fall below the average, both having only 0.12 per cent. The other soil types contain higher than 0.14 per cent and there is even one that exceeds the higher supply of 0.30 per cent which is Jasaan clay, stony phase, having 0.33 per cent. From these results, therefore, it can be stated that the soils in Misamis Oriental do not need a fairly high application of nitrogenous fertilizers. Nitrogenous fertilizers may be supplied only for maintenance either as in organic or inorganic form. As the organic form, application of guano or green manure may be practiced. The inorganic form may be supplied with the application of commercial fertilizers like ammonium sulfate, ammonium nitrate, etc., in the amount of about 150 kg. to a hectare. Leguminous crops which produce a lot of nodule bacteria may also be planted.

Soil organic matter.—The nature, quality and amount of organic matter affects our agricultural cropping system. Organic matter exerts a controlling influence on soil properties, including productivity, and without it the surface layer of the earth could hardly be correctly designated as soil. It is one of the most easily exhausted resources of soil through surface erosion and crop removal. The largest part of organic material of soil is made up of roots, leaves and stems of plants in various stages of decay. Much of the organic matter of soils in farm lands comes from the root system of crops and the mature stems and leaves after the seed has been harvested. To protect the soil from erosion then, crops are planted and plowed under while still green. Farm manures also provide the opportunity of returning large quantities of plant material to the soil. They are worked into the soil to a considerable extent by plowing or other tillage practices. Due to natural processes also, the plant leaves and stems in timber and grazing lands are deposited on the soil surface and become incorporated therein. The amount of organic material within these soils is largely determined by the nature of the root system and whether the plants are grasses or trees and shrubs.

Leguminous crops are considered especially valuable as sources of organic matter; the primary reason is that they have the ability to increase the nitrogen content of soil. In this connection, however, there is a difference between legumes and non-legumes in that not only do they vary in nitrogen-gathering ability but also that legumes contain more nitrogen in proportion to their carbon content.

The decomposition of organic matter in the soil is a biochemical process and any factor that affects the activities of the soil organisms will necessarily affect the rate of organic matter decay. (48) Several factors which have a bearing on the rate of organic matter decomposition are: (1) the nature of the plant material (including such points as the kind of plant, age of plant, and chemical composition) (2) soil (including aeration, temperature, moisture, acidity and fertility level); and (3) climatic factors (the effects of moisture and temperature are particularly influential). Due to a higher content of water-soluble constituents, a higher nitrogen content, a narrower carbon-nitrogen ratio, and a smaller percentage of lignin and other constituents resistant to decomposition, the younger the plants, the more rapid will be their decomposition when incorporated into the soil.

Soil conditions favorable for the growth of common crop plants are also favorable for organic matter decomposition. The degree of soil aeration is one of the most influential factors in this respect. Organic matter decay is largely a burning or oxidation process, and the greater the degree of aeration the greater, in general, will be the rate of decay. Soil moisture and soil temperature are controlled largely by climatic influences. Other conditions favorable, the rate of soil organic matter decay increases with an increase in soil moisture to a point where aeration is inadequate. The rate of decay increases with increasing temperature to a certain limit, if all other conditions are assumed to be constant and favorable.

Humus denotes soil organic matter which has undergone extensive decompostion. (48) It is not a homogeneous substance it has no definite chemical composition. It is a dark mass consisting of the residues of plant and animal materials together with the synthesized cell substances of soil organisms. Humus is not static but dynamic in soils; it is continually undergoing change.

The C: N ratio in fresh plant materials that are commonly added to soils is usually from about 80:1 in mature straw to 12 to 20:1 in leguminous green-manure crops (48). In any case, the ratio will narrow or drop to about 10:1 in a relatively short time after these materials have been incorporated into soils In other words, the C:N ratio of humus in mineral soils is roughly 10:1. This means that for each pound of nitrogen in the soil, there exists about 10 pounds of carboon.

Humus is highly colloidal and, as clay, it functions as an acidoid or micelle and usually carries a large number of negative charges. It is composed principally of C, H, O, N, S, and P, in contrast to the mineral acidoids, which are composed chiefly of Si, O, Al, and Fe.

The soil organic matter determinations are usually based on organic carbon analysis, the results of which are multiplied by the conventional factor 1.724. This factor, 1.724, was obtained by assuming that the carbon content of the organic matter is fifty-eight (58) per cent. The amount of organic carbon is usually related to the total nitrogen content, and under those conditions, nitrogen analysis may be taken as an approximate index of organic matter.

A high percentage of nitrogen and low percentage of carbon gives a narrow ratio, and a lower percentage of nitrogen and a higher percentage of carbon gives a wider ratio. In this case, the narrowest ratio is 1:11.52 that of Faraon clay, and the widest ratio is 1:23.10 — that of Lourdes clay loam. The organic matter content of soils of Misamis Oriental ranged from 3.90% that of Umingan clay loam to 13.10% that of Jasaan clay, stony phase. As already mentioned, a high nitrogen content generally means a high percentage of organic matter—and Jasaan clay, stony phase proves this.

Phosphorus.—Phosphorus is contained in the threads of plant cells that pull the materials of the cells' interior apart to form two new cells. If the supply of phosphorus is scanty, the rate of cell division is slowed down; thereby, leaving the plant stunted and spindling.

The total supply of phosphorus in soils is relatively small, and the available supply usually falls short of crop requirements. It is usually the first element that becomes deficient after the soil is brought under cultivation. Like nitrogen, phosphorus is a constituent of every living cell. It is present in seeds in larger amounts than in any other parts of plants, although it is found extensively in the young growing parts.

Available phosphorus, in sufficient quantities, is necessary for normal transformations of carbohydrates in plants as in the changing of starches to sugars. It is also necesary for the assimilation of fats in plants, and apparently it increases the efficiency of the chloroplastic mechanisms. It also enters into the composition of nuclear compounds in cells. Its presence aids the plant in taking up potassium and tends to counteract the effects of excess nitrogen. An excess of this element, however, in proportion to the supplies of other required nutrients may decrease yields, especially on the higher soils.

Phosphorus has the most obvious effect on the root system of plants. Phosphorus-starved plants tend to have a stunted root system which decreases their feeding zone, and thus the plants are less able to withstand adverse conditions.

Since most soils have a marked capacity to convert inorganic soluble phosphates into insoluble and unavailable forms, the behavior of this element in relation to the acidity or alkalinity of the soil and its content of clay and organic matter is of tremendous economic importance.

Because of the destruction of organic matter by farming practices and the loss of phosphorus through removal of crops and erosion, phosphorus is one of the elements that is generally deficient in soils. A phosphorus shortage may be identified by the plants appearing usually dark green. Purplish tints in the leaves and stems are seen in corn and small grains. Legumes are stunted and show purplish-green color of leaves. Tobacco manifests a dark green color and a delay in maturity.

The available phosphorus content necessary to maintain a normal plant growth varies according to climate and soil. Truog, in his method of analysis, set a minimum limit of readily available phosphorus at 37.5 p.p.m. for good heavy or clay soils and 15 p.p.m. for lighter or sandy soils under Wisconsin, U. S. A. conditions. For certain sections in the southern U. S. A., he suggested that 10-15 p.p.m. of readily available phosphorus might maintain a good crop. Marfori (44) found that in the Philippines there was little response on phosphatic fertilizer of rice soil having available phosphorus of 37.3 p.p.m. according to the Truog method. However, 30 to 40 p.p.m. of

available phosphorus might be a reasonable minimum requirement for a good crop of rice.

The available phosphorus content of soils from Misamis Oriental are show in table. 14. The available phosphorus content ranges from 3 p.p.m. that of Bolinao clay to 194 p.p.m. that of Umingan clay. Six of the different soil types have a somewhat high available P. They are San Manuel loam, 73 p.p.m.; Umingan clay, 194 p.p.m.; Bantog clay, 44 p.p.m.; Matina clay, 45 p.p.m.; Alimodian clay loam, 90 p.p.m.; and Jasaan clay, stony phase, 52 p.p.m. The others have available phosphorus content ranging from 3 to 28 p.p.m., which fall below the minimum requirement for good crop growth. Hence, it is very necessary that the application of commercial phosphatic fertilizers be made on these phosphorus deficient soils. Commercial fertilizers like ammophos containing 16 per cent nitrogen and 20 per cent phosphoric acid (P_2O_5) and single superphosphate containing 20 per cent of phosphoric acid (P_2O_5) may be used for application. Ammophos or superphosphate at the rate of 50-300 kilograms to a hectare may be applied to these deficient soil types according to their phosphorus contents.

Potassium.—Potassium is available to plants only in small amounts although the total content of potassium in soils is usually high. This fact then becomes a major concern to the farmers. It is usually more often needed and in larger quantities in the light soils (sandy soils) and mucks than in the heavy soils. In potash (K_20), it makes up about 40 per cent of the ash of most plants, and is not localized in any part of the plant to the extent that phosphorus is. Correlation between the potash content of ashed plants and potash of the soils have been made. The Neubauer method which makes use of rice or rye seedlings as the indicator takes into consideration the amount of potash in the soil available to plants. In some crops, it may tend to accumulate in the leaf and stem rather than in the grain.

Potassium is vital for photosynthesis in the production of carbohydrates and proteins. It is essential for the development of chlorophyll, production of starch and sugar, and then in the synthesis of fats and albuminoids. It also improves the vigor of the plants and increase resistance to pests and diseases. Millar and Turk (48) states that potassium increases plumpness in grain and makes the stalks or stems of plant more rigid, thus minimizing lodging. Ears of corn produced on potassium deficient soils frequently are chaffy, tapering at the tips, and the kernels are loose on the cob because they are not well filled with starch.

Not much is known about the function of potassium in plants. More is known about what happens to a plant when this element is deficient. From this information, theories were advanced that potassium enhances the plant's ability to resist disease, cold, and other adverse conditions. It also functions in other processes whereby sugars are made from carbon dioxide and water.

Potassium encourages the development of the root system of plants. An excess of this element may delay maturity. In general, however, it has a balancing effect on both nitrogen and phosphorus with respect to the maturation processes. The intake and retention of water seem to be regulated to some extent by the quantity of potassium present, hence, affecting the resistance of the plant to injury from drought and frost.

Where a deficiency exists, the addition of potassium affects the quality of tobacco, improves the quality in potatoes, and increases the sugar content of sugar beets.

Tobacco requires a great deal of potassium, the plant shows striking symptoms when potassium is not present in adequate quantity. The lower leaves of the tobacco plant suffering from potassium hunger shows a typical mottling, a loss of green color (chlorosis) at their tips and margins which is later followed by necrosis or development of specks of dead tissues. The dead areas may fall out, producing a rugged appearance of the leaf.

Potassium salts are needed in abundance for the normal growth and development of the corn plant from the time the seed germinates until the plant is matured. The plants are protected from excessive losses of water during periods of drought, and it lessens the injuries due to low temperatures. Because of its inability to move from one part of the plant to another, potassium hunger appears first in the older leaves. The younger parts of the plant draw the potassium away from this older parts. Healthy, vigorous corn plants always contain large amounts of potassium salts in their tissues, whether in the seedling stage or in plants approaching maturity.

The diminution in the rate of growth of corn seedlings and young plants is a first sign of potassium deficiency. The young leaves turn yellowish-green to yellow. The edges and tips become dry and appear scorched or fired. When these foliage symptoms are recognized early in corn plants, muriate of potash must be applied to correct the deficiency. Make the application prior to the last cultivation.

Potassium becomes available slowly in many soils, and there is no way of increasing the rate of liberation in depleted soils enough to meet the requirements of the corn crop satisfactorily. It has been proved that when the corn crop suffers from a lack of enough available potassium for normal growth and production, all of the other crops in the same rotation will also show response to potash fertilization. In many fields where limestone and phosphate have been used for growing legumes in the rotation with corn, potash deficiencies appear because of the large quantities of potassium removed in the increased hay and grain yields.

The major portion of the soil potassium exists in the difficult available form. The water-soluble potassium is much smaller than the available and is the one easily lost through drainage and leaching. 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 considered fixed or stored for future use by the plants.

Bray (24) found that for Illinois and corn belt soils, no response to potassium fertilization was noted when the soils contained 150 p.p.m. or more of available potassium. Murphy (49) also reported that for Oklahoma soils containing less than 60 p.p.m. of replaceable potassium, response was favorable.' Those soils containing 100-124 p.p.m. of available potassium have doubtful crop responses and those from 155-170 p.p.m. or more have no response at all. Locsin (38) however, reported that in his experiments on potash fertilization on sugar cane in Victorias, Negros Ocidental, 85 p.p.m. or less gave positive crop response to potash applications while soils containing 151 p.p.m. or more gave negative response.

From these results obtained abroad and here in the Philippines, it may be safe to assume tentatively that 100-150 p.p.m.

is the average minimum available requirement of most crops such as rice, corn and sugar cane. From table 13, it can be observed that the K content ranged from 68 p.p.m. that of Alimodian clay loam to 293 p.p.m. that of Camiguin clay. With 100 p.p.m. as the basis for minimum available requirement, there are only three soil types which need potassium fertilization. They are Umingan clay loam (96 p.p.m.), Alimodian clay loam (68 p.p.m.) and Bolinao clay (93 p.p.m.). It is therefore very necessary that potassic fertilizers be applied to these soils either as muriate of potash, which contains 60% K_2O or potassium sulfate, which contains 50 per cent K_2O depending on the amount of its constituent recommended and on the kind of crop to be grown. The other soil types do not need any. Their available K content are above 100 p.p.m. or 150 p.p.m.

Calcium.—Calcium is one of the essential plant nutrients which affects the soil physically, chemically and biologically. Calcium is leached out of the soil as calcium carbonate when carbon dioxide in the soil solution acts as a potent solvent for calcium compounds. This accounts for the heavy losses that take place. Soil acidity is then increased.

It is probable that more calcium than sodium has been carried into the oceans. Sodium salts make the sea salty and the sea would be milky from calcium salts except for the fact that the calcium has been combined into the shells of marine animals to be redeposited as limestone. This is one of the interesting examples of how calcium is used by animals to build bony materials. In plants, it is built into the walls of the cells to form a productive "sieve" for the nutrients to seep through in passing into the cells. It also acts as a cement between the walls of the cells to hold them together. It is generally believed, too, that it has an influence in the translocation of carbohydrates and certain mineral elements within the plant and on the development of roots.

Calcium may also influence either favorably or unfavorably the absorption of other elements. Within certain limits, for example, an inverse relationship has been found between the intake of calcium and potassium by plants. It may counteract to some extent the toxic effects of high concentrations of potassium, magnesium and sodium, and possibly, boron. An abnormal performance of plant functions will result with any

upset in the balance due to an excess or lack of any of them. What may appear to be an excess of calcium in a plant may be a lack of one or more of these other elements, and the remedy may be to add the deficient element or elements instead of cutting down the apparent excess of calcium. Similarly, an apparent excess of potassium, magnesium, or boron may really be a deficiency of calcium.

The amount of calcium in a soil determines the physical structure of that soil. A soil which contains high calcium is granular, porous, easy to work with, and has better tilth. The acidity of acid soils is neutralized by lime. Lime also corrects the toxic effects caused by such acidity of plants. Flocculation of soil colloids is also effected.

As a general rule, a relatively high percentage of the phosphorus in soils well supplied with lime is available for plant use, and the phosphorus of calcium—deficient acid soils is in relatively unavailable forms even though the total phosphorus content is comparatively high. The availability of soil phosphorus is affected by the acidity of the soil. It is generally most readily available to plants in neutral or slightly acid soils. With increasing acidity, its availability decreases. It combines with aluminum and iron compounds in strongly acid soils, forming relatively insoluble aluminum and iron phosphate compounds. In the presence of excess calcium carbonate (about 2 per cent) in alkaline soils, it combines with calcium forming tricalcium phosphate, which is of low solubility. Tricalcium phosphate is more soluble than the phosphates of aluminum and iron.

When acid soils are limed, the tendency is to make the phosphorus more available by converting a part of it that is present as aluminum and iron phosphate to the more available calcium phosphates. From the standpoint of plant use, the more desirable forms are the monocalcium and dicalcium phosphates. It is also likely that liming results in the liberation of the organic phosphorus in the soil through stimulation of the decomposition processes. However, it is obvious that lime alone will not solve the problem of phosphorus availability because many soils are so depleted of phosphorus that lime has little effect in increasing crop yields unless accompanied by applications of phosphate fertilizer.

When soils become deficient in bases, the solubility of Al, Fe, and Mn increases; in strongly acid soils, the high concentrations of these elements may be toxic to crop plants. Excess quantities of these elements may become available at pH values below 5.5. Soils having reactions between pH 5.5 and pH 7.0 usually supply plants with sufficient quantities of both iron and manganese, but at pH values above 6.5 or 7.0, especially in sandy soils, they may become insoluble to such extent that plants are unable to satisfy their needs. Caution is therefore necessary in the use of lime. Too much lime may create iron and manganese defiency.

Calcium is closely associated with certain important microbiological processes. Its more important effects on the soil population are in (1) promoting the decomposition of organic matter, (2) making conditions favorable for nitrification and sulfofication; and (3) providing favorable conditions for the growth and functioning of both symbiotic and non-symbiotic nitrogen-fixing bacteria. In the above mentioned processes, it is not necessarily a matter of changing the pH, but one of supplying soluble calcium.

Lime may be used as a preventive of certain types of plant diseases which occur only in acid soils. An alkaline soil caused by the use of too much lime is likely to depress certain desirable microbiological processes, such as nitrification and the decomposition of organic matter. It is generally believed, although it does not always occur, that the application of lime in amounts sufficient to make a soil neutral or alkaline forms potato-scab disease.

Some effects of liming on plant composition as reported by Smith and Hester (60) are: (a) calcium content of the cabbage leaves have been increased from 4.42 per cent to as much as 7.53 per cent, (b) the yield of tomatoes was increased to more than double together with the Vitamin C or ascorbic acid content, and (c) corn grain showed an increase of 40 per cent in the protein content. Madamba and Hernandez (42) in their experiment in the effect of lime found that the increased yield of upland rice was due to the application of lime.

In table 14 the results of the analysis for the available calcium content of the soils of Misamis Oriental ranged from 500 p.p.m. that of Jasaan clay to 25,000 p.p.m. that of Faraon clay. Four of the soil types still need application of lime because they have a rather very low calcium content. They are Jasaan clay, Mambajao clay, Jasaan clay loam and Caminguin clay having 500, 900, 1400 and 1900 p.p.m. respectively. Bolinao clay and Faraon clay have very high calicum content—17,800 and 25,600 p.p.m. respectively, even exceeding the higher limit of 6,000 p.p.m. for average calcium content of Philippine soils. The other soil types fall within the average range of 2,000-6,000 p.p.m. of calcium in Philippine soils.

Magnesium.—The key element in the molecule of chlorophyll is magnesium. Chlorophyll is the green pigment in plants that traps the energy from the sun and makes plant life possible. This pigment starts the chain of events that begins with the green plants and goes on up through animals and man. It is credited for being a companion for phosphates combining with it so that the latter can be moved to their proper places in the plant in the form of magnesium phosphate compounds.

Magnesium deficiency results in a characteristic discoloration of the leaves. Premature defoliation of the plant also results. The chlorosis of tobacco, known as "sand drown" is due to a magnesium deficiency. Cotton plants, suffering from a lack of this element, produce purplish red leaves with green veins. Leaves of sorghum and corn become striped; the veins remaining green, but the areas between the veins become purple in sorghum and yellow in corn. The lower leaves of the plant are affected first. In legumes, the deficiency is shown by chlorotic leaves.

In various parts of the Southern States and even in Massachussets, magnesium deficiency in corn has been reported. This deficiency in some cases is believed to be intensified by the unbalanced plant-nutrient conditions resulting from the continued use of sodium salts in fertilizing other crops in the corn rotation. Usually, however, nitrogen and phosphorus deficiency occur in these acid soils, and until they are corrected the magnesium deficiency may not become dominant. Magnesium deficiency is most likely to be present in sandy soils particularly during seasons of heavy rainfall. The addition, however, of magnesium-bearing fertilizers principally of dolomitic limestone and magnesium sulfate on the magnesium deficient soils has become common practice.

The soils of Misamis Oriental contain magnesium in the amount of 210 p.p.m. to 4,890 p.p.m. For Philippine soils, soil types that rated high in crop productivity gave about 600-1,700 p.p.m. of available magnesium on the average. With this as basis, seven soil types fall below the lower limit. They are Jasaan clay, Mambajao clay, Jasaan clay loam, San Manuel loam, Umingan clay loam, Alimodian clay loam and Camiguin clay of 300, 210, 300, 470, 390, 210 and 210 p.p.m. of available magnesium respectively. These soils then need an application of magnesium-bearing fertilizers.

Manganese.—One of the trace elements needed by plants is manganese. A lack of sufficient manganese or boron is most likely associated with calcareous or heavy limed soils. Manganese seems to act as a two-banded (double valence) reception committee, of which zinc and copper are also members to greet the other nutrient ions as they enter the plant cell and to direct them to their respective positions for carrying out their functions in the plant. In other words, they are catalysts. Trace elements, in quantities larger than the plant needs, are likely to be toxic or poisonous to the plant although the actual quantity may still be small. Excessive as well as deficient amounts will produce certain characteristic symptoms.

Investigations have been made about this element in relation to its influence on soil. Nitrogen-fixation and ammonification in the soil are dependent upon its presence. Manganese is usually present in sufficient quantities in most soils. It need not be added in fertilizer mixture except in soils where a definite deficiency has been noted. A deficiency in this element is most likely to be found in alkaline soils, especially those which originally were acidic and have been heavily limed. Manganese is also usually needed for certain crops on alkaline muck soils.

In the absence of sufficient manganese, tomato, bean, oat, tobacco, and various other plants are dwarfed. Associated with this dwarfing is a chlorosis of the upper leaves of the plant, and the leaves become spotted. The "gray speck" of the roots has been attributed to a shortage of this element in some soils.

It has frequently been observed that the leaves of onions growing in alkaline muck soils become dwarfed and curled during growth and that the bulbs remain immature at harvest time. On similar soils, celery becomes yellow; spinach, lettuce, and potatoes are chlorotic and frequently unmarketable.

The soils of Misamis Oriental when analyzed for available manganese were found to contain variable amount of such element. Bolinao clay has a trace for manganese. Faraon clay and Jasaan clay, stony phase both contain 4 p.p.m. only. These three soil types may be corrected for this deficiency(basing 15 p.p.m. as the minimum requirement) by adding manganese sulfate. The other soil types have higher manganese content—ranging from 19-390 p.p.m. These soils, however, do not need any manganese application.

Iron.—Although iron is needed in a very little amount yet it is a most essential element. Iron is usually available to all plants in acid soils, but in some neutral or alkaline soils, it is so insoluble that some plants may have difficulty in absorbing enough. Where excessive amounts of soluble phosphates have been added to the soil, the iron may be made unavailable to plants by being precipitated as an insoluble iron phosphate. This may happen in acid as well as in alkaline soils. It is more likely to occur in sandy than in clay soils, because the latter have greater power to fix or "lock up" excessive soluble phosphates.

The availability of iron also varies widely with the degree of soil aeration, being higher under anaerobic condition. Occasionally, soils are found which are deficient in available iron, and on soils containing considerable quantities of lime, the movement and activity of the iron within plants are reduced in some manner by the presence of excess calcium. Investigations indicate a relationship between the solubility of iron and the supply of manganese. There are some reasons for thinking that a deficiency of manganese in the soil leads up to an iron toxicity.

Soils of Misamis Oriental have been found to contain low amount of iron. Although the total iron content of an average agricultural soil goes as high as five per cent (50,000 p.p.m.) or more, the amount of available iron (to plants) is very small. Several representative soil types from various parts of Luzon which rated high or at least medium in crop productivity had been analyzed for available iron in our laboratory following a modified Peech and English method. The results obtained ranged from about 2 to 30 p.p.m. of available iron. With these figures as basis there are only three soil types that fall within the range. They are Jasaan clay, San Manuel loam and Camiguin clay. The other soil types contain trace amount and 1 p.p.m. only.

FERTILIZER AND LIME REQUIREMENTS

Fertilizers, in a broad sense, include all materials that are added to soils to increase the growth, yield, quality, or nutritive value of crops. Although fertilizers may affect the soil and plant growth in a number of different ways, they are used primarily to increase the supply of available plant nutrients in the soil and to balance the plant-nutrient ratio.

It is customary to speak of fertilizers and fertilizer mixtures as containing nitrogen (N), phosphoric acid (P_2O_5), and potash (K_2O) instead of nitrogen (N), phosphorus (P), and potassium (K). Fertilizers do not consist of the elements nitrogen, phosphorus, and potassium as such, but they are combined with other elements to form either organic or inorganic compounds. Fertilizer materials are classed as nitrogenous, phosphatic, or potassic depending on whether their principal constituent is nitrogen, phosphorus, or potassium, although some materials can be placed in more than one of these categories.

Table 16 shows the fertilizer and lime requirements of the different soil types of Misamis Oriental for corn, coconut, and rice based on their average chemical analysis.

Only Jasaan clay, Mambajao clay, Jasaan clay loam and Camiguin clay need application of lime both to increase the soil reaction or pH value and to increase the calcium content.

Jasaan clay, stony phase does not need any application of nitrogen anymore. For corn, the rate of application of ammonium sulfate analyzing 20% N to increase the nitrogen content ranges from 150-300 kilograms per hectare. The same rate is required for coconut and rice.

San Manuel loam, Umingan clay, Bantug clay, Matina clay, Alimodian clay loam and Jasaan clay, stony phase have high content of phosphorus and as such do not need application of phosphatic fertilizers. The other soil types, however, need phosphatic fertilizer application like superphosphate containing 20% P_2O_5, varying in amount from 50-300 kg. per hectare depending on the phosphorus content for corn, coconut and rice.

The amount of potassic fertilizer to be applied varies between corn and coconut. Corn requires a larger amount of

TABLE 16 *Fertilizer and lime requirements of the different soil types of Misamis Oriental.*

SOIL TYPES	Agricultural lime *	Ammonium sulfate (20% N)	Super-phosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	Tons/Ha.	Kg./Ha.	Kg./Ha.	Kg./Ha.
		For Corn		
Jasaan clay	7.50	150	300	50
Mambajao clay	5.50	150	250	—
Jasaan clay loam	3.00	150	300	50
San Manuel loam	—	150	—	—
Umingan clay	—	150	—	100
Bantog clay	—	150	—	—
Matina clay	—	150	—	50
Umingan clay loam	—	150	300	150
Alimodian clay loam	—	300	—	200
Bolinao clay	—	150	300	150
Faraon clay	—	150	250	—
Lourdes clay loam	—	300	300	50
Camiguin clay	0.50	150	50	—
Jasaan-Bolinao complex	—	150	100	—
Jasaan clay, stony phase	—	—	—	50
		For Coconut and Rice		
Jasaan clay	3.70	150	300	50
Mambajao clay	2.75	150	250	—
Jasaan clay loam	1.50	150	300	50
San Manuel loam	—	150	—	—
Umingan clay	—	150	—	50
Bantog clay	—	150	—	—
Matina clay	—	150	—	50
Umingan clay loam	—	150	300	100
Alimodian clay loam	—	300	—	150
Bolinao clay	—	150	300	100
Faraon clay	—	150	250	—
Lourdes clay loam	—	300	300	50
Camiguin clay	0.25	150	50	—
Jasaan-Bolinao complex	—	150	100	—
Jasaan clay, stony phase	—	—	—	50

* Limestone ($CaCo_3$) pulverized to 20 mesh and about 50% to pass 100 mesh.

potash in its tissues, naturally a high application of potassic fertilizer must be made to balance or maintain the potassium content of the soil. The amount of application of muriate of potash analyzing 60 per cent K_2O for corn is from 50 to 200 kg. per hectare; while that for rice and coconut is 50 to 150 kg. per hectare. Mambajao clay, San Manuel loam, Bantog clay, Faraon clay, Camiguin clay and Jasaan-Bolinao complex, because they have high content of available potassium, do not need potassic fertilizer application anymore.

The time and method of application determines largely the value of fertilizer mentioned above. When applied at the right time and in the proper manner, they stimulate the growth of the crop and produce satisfactory returns.

Various methods of applying fertilizers to the soil depending upon the nature of the crop and the conditions obtaining on the plantation are known. Two things must always be kept in mind in applying fertilizers: (1) the necessity for uniform distribution and (2) the necessity of thoroughly incorporating the fertilizer with the soil. These conditions are essential to the success of manuring. The reason is obvious; for, where the fertilizer is unevenly distributed some areas receive abundant plant food while the others receive little or possibly none. There must be even distribution of fertilizers to provide each plant with sufficient food and to prevent waste of manures and fertilizers.

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

Fertilizers, when applied to permanent crops, are distributed or restricted to a comparatively small area around the plants — usually the area shaded by branches. The development of an extensive root system is therefore encouraged. The plant food itself is also availed of more fully by the plant if there is enough moisture in the soil and also better to resist drought.

The right time of application is another essential factor. For most crops, there are certain general rules as to the time of applying fertilizers.

Nitrogenous fertilizers, especially the nitrates, are applied during growth as a top dressing. They are applied before watering in irrigated areas. Fertilizers like the ammonium sulfate and nitrate of soda should be applied when the plants are not wet because the fertilizers falling on the wet leaves is apt to "burn" them. Apply the less soluble nitrogenous manures some weeks before planting so that the nitrogen will be in a readily available form at the time the plants need them.

Apply superphosphate to the soil just before planting, especially where the soil is light. The less soluble forms of phosphates should be applied a few weeks before planting or sowing in order that they may be rendered soluble and readily assimilable by the time they will be needed by the plants.

For annual crops, potash should be broadcast and worked into the soil some time before planting. In this way, potash is dissolved in the soil and becomes available at the time the plants need it.

For better results apply fertilizers annually or even twice a year, rather than in large applications at long intervals.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN MISAMIS ORIENTAL PROVINCE

Common name	*Scientific name*	*Family name*
Abaca	*Musa textilis* Nee	Musaceae
Achuete	*Bixa orellana* Linn.	Bixaceae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Alibangbang	*Bauhinia malabarica* Roxb.	Leguminosae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Anonas	*Anona reticulata* Linn.	Anonaceae
Aroma	*Acacia farnesiana* (Linn.) Wild	Leguminosae
Atis (sugar apple)	*Anona squamosa* Linn.	Anonaceae
Arrowroot	*Marantea arundinacea* Linn.	Marantaceae
Avocado	*Persea americana* Mill	Lauraceae
Balete	*Ficus benjamina* Linn.	Moraceae
Balimbing	*Averrhoa carambola* Linn.	Oxalicaceae
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Banana	*Musa sapientum* Linn.	Musaceae
Batao	*Dolichos lablab* Linn.	Leguminosae
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineae
Benguet Pine	*Pinus insularis* Endl.	Pinaceae
Breadfruit	*Artocarpus communis* Forst	Moraceae
Buri	*Corypha elata* Roxb.	Palmae
Cabbage	*Brassica oleracea* Hort	Cruciferae
Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Casoy	*Anacardium occidentale* Linn.	Anacardiaceae
Cassava	*Manihot esculenta* Crantz	Euphorbiaceae
Chico	*Achras sapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea arabica* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Corn	*Zea mays* Linn.	Gramineae
Cowpeas	*Vigna sinensis* (Linn.) Savi.	Leguminosae
Dayap	*Citrus aurantifolia* (Christm) Swingle	Rutaceae
Duhat	*Eugenia cumini* (Linn.) Druce	Myrtaceae
Durian	*Durio zibethinus* Murr.	Bombacaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculenta* (Linn.) Schatt	Araceae
Ginger	*Zingiber officinale* Rose	Zingiveraceae

Common name	*Scientific name*	*Family name*
Guava	*Psidium guajava* Linn.	Myrtaceae
Guayabano	*Anona muricata* Linn.	Anonaceae
Ipil-ipil	*Leucaena glauca* (Linn.) Millsp.	Leguminosae
Kalabasa	*Cucurbita maxima* Duch	Cucurbitaceae
Kaldis	*Cajanus cajan* (Linn.) Millsp.	Leguminosae
Kamachile	*Pithecolobium dulce* (Roxb) Benth.	Leguminosae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Kangkong	*Ipomoea aquatica* Forsk	Convolvulaceae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Katurai	*Sesbania grandiflora* (Linn.) Pers.	Leguminosae
Kondol	*Benincasa hispida* (Thumb) Gogn.	Cucurbitaceae
Lanzones	*Lansium domesticum* Correa	Meliaceae
Lauan	*Anisoptera thurifera* (Blanco) Blume	Dipterocarpaceae
Lumbang	*Aleurites moluccana* (Linn.) Willd	Euphorbiaceae
Mabolo	*Diospyros discolor* Willd.	Ebenaceae
Madre cacao	*Gliricidia sepium* (Jacq) Steud.	Leguminosae
Macopa	*Eugenia mallaccensis* Linn.	Myrtaceae
Malungay	*Moringa oleifera* Linn.	Moringaceae
Mandarin	*Citrus nobiles* Lour	Rutaceae
Mango	*Mangifera indica* Linn.	Anarcadiaceae
Molave	*Vitex parviflora* Juss	Verbenaceae
Mungo	*Phaseolus aureus* Roxb	Leguminosae
Mustard	*Brassica integrifolia* (West) O. E. Schultz	Cruciferaceae
Nangka	*Artocarpus heterophyllus* Lam.	Moraceae
Narra	*Pterocarpus indicus* Willd.	Leguminosae
Nipa	*Nypa fructicans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Orange	*Citrus aurantium* Linn.	Rutaceae
Pandan	*Pandanus tectorius* Sol.	Pandanaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Patani	*Phaseolus lunatus* Linn.	Leguminosae
Patola	*Luffa cylindrica* (Linn.) M. Roem	Cucurbitaceae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Pepper (Black)	*Piper negrum* Linn.	Piperaceae
Pepper (Sili)	*Capsicum annum* Linn.	Solanaceae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pummelo	*Citrus maxima* (Burm.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferaceae
Rattan	*Calamus spp.*	Palmae
Rain tree (Acacia)	*Samanea saman* Merr.	Leguminosae
Rice	*Oryza sativa* Linn.	Gramineae
Rimas	*Artocarpus communis* Forst	Moraceae

Santol	*Sandoricum koetjape* Meer	Meliaceae
Saluyot	*Chorchorus olitorius* Linn.	Liliaceae
Sincamas	*Pachyrrhizus erosus* Linn.	Leguminosae
Siniguelas	*Spondias purpurea* (Linn.) Urb. .	Anacardiaceae
Sitao	*Vigna sesquipedalis* Fruw	Leguminosae
Soybean	*Glycine max* (Linn.) Merr.	Gramineae
Sugar cane	*Saccharum officinarum* Linn.	Convolvulaceae
Sweet potato	*Ipomea batatas* (Linn.) Poir	Leguminosae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Tamarind	*Tamarindus indicus* Linn.	Leguminosae
Teak	*Tectona grandis* Linn.	Verbenaceae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Willd. ..	Solanaceae
Tugue	*Dioscorea esculenta* (Lour) Burkill	Dioscoreaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Dutch) Rusby	Cucurbitaceae

LITERATURE CITED

1. Alicante, M. M., D. Z. Rosell, R. Isidro and S. Hernandez. Soil Survey of Bulacan Province, Philippines. Dept. of Agri. and Comm. Technical Bull. 5 (1936) 28 pp. Bureau of Printing, Manila.
2. Alicante, M. M., D. Z. Rosell, R. T. Marfori and S. Hernandez. Soil Survey of Pangasinan Province, Philippines. Dept. of Agri. and Comm. Soil Report 7 (1940) 47 pp. Bureau of Printing, Manila.
3. Alicante, M. M., D. Z. Rosell, A. Barrera and I. Aristorenas. Soil Survey of Iloilo Province, Philippines. Dept. of Agri. and Comm. Soil Report 9 (1947) 64 pp. Bureau of Printing, Manila.
4. Alicante, M. M., D. Z. Rosell, A. E. Mojica, R. Samaniego and F. B. Lopez. Soil Survey of La Union Province. Philippines. Dept. of Agri. and Nat. Resources. Soil Report 12 (1950) 75 pp. Bureau of Printing, Manila.
5. Alicante, M. M. and J. P. Mamisao. 1948. Methods of Conservation Farming, Dept. of Agriculture and Natural Resources, Technical Bull. 17. pp. 1-27
6. Alicante, M. M., D. Z. Rosell, A. Barrera and I. Aristorenas, 1947. Soil Survey of Iloilo Province, Philippines. Department of Agriculture and Natural Resources, Soil Report 9.
7. Alicante, M. M., D. Z. Rosell, F. B. Bernardo, I. Romero and I. Engle, 1948. Soil Survey of Laguna Province, Philippines. Department of Agriculture and Natural Resouurces, Soil Report 10.
8. Alicante, M. M., D. Z. Rosell, J. A. Mariano, F. L. Calimbas and J. A. Tingzon. 1949. Soil Survey of Bataan Province, Philippines, Department of Agriculture and Natural Resources, Soil Report 11.
9. Alicante, M. M., D. Z. Rosell, A. E. Mojica, R. Samaniego and F. B. Lopez, 1950. Soil Survey of La Union Province, Philippines. Department of Agriculture and Natural Resources, Soil Report 12

10. Alicante, M. M., D. Z. Rosell, F. L. Calimbas, F. B. Lopez and L. Engle. 1951. Soil Survey of Zambales Province, Philippines. Department of Agriculture and Natural Resources, Soil Report 13.
11. Alicante, M. M., D. Z. Rosell, A. Barrera, J. O. Jaug, and L. Engle. 1951. Soil Survey of Negros Occidental Province, Philippines. Department of Agriculture and Natural Resources, Soil Report 14.
12. Alicante, M. M., D. Z. Rosell, A. E. Mojica, I. J. Aristorenas and J. A. Tingzon. 1952. Soil Survey of Bohol Province, Philippines. Department of Agriculture and Natural Resources, Soil Report 15.
13. Anonymous. Yearbook of the Philippine Statistics 1946. Bureau of the Census and Statistics (1947) 126-175. Bureau of Printing, Manila.
14. Anonymous. 1949. Philippine Agriculture. Volume I. Field Crops. Published by the College of Agriculture. University of the Philippines. College, Laguna.
15. Anonymous. 1947. Scientists meet the challenge of Florida's varied soils. Fertilizer Review, vol. XXII, No. 3. pp 17-18
16. Anonymous. Diagnostic Techniques for Soils and Crops. 1948. Edited by Firman E. Bear and Hermania B. Kitchen. American Potash Institute, N. W., Washington, D.C. p. 308.
17. Arciaga, Antonio M., and N. L. Galvez. 1948. The effect of soil reactin (pH) on the growth of petsai plants and on their nitrogen calcium and phosphorus content. The Philippine Agriculturist 32: 55-59.
18. Association of Official Agricultural Chemists. 1945. Official and Tentative Methods of Analysis, ed. 6. Assoc. of Off. Agr. Chemists, Washington, D.C.
19. Baver, L. D. 1935. Soil Erosion in Missouri. College of Agriculture, Agri. Expt. Station, University of Missouri. Bull. 349. Reprinted 1941. pp. 1-64
20. Bennett, H. H. 1941. Soils and Security. U. S. Dept. of Agriculture. Soil Conservation Service. pp. 1-25
21. Bennett, H. H. and W. C. Lowdermilk, 1938. General aspect of the soil-erosion problem. Soils and Men. U. S. Dept. of Agriculture Yearbook 1938. pp. 581-608
22. Besson, Kenneth C. 1941. The mineral composition of crops with particular reference to the soils in which they were grown. U. S. Dept. of Agri. Misc. Pub. 369.
23. Bouyoucos, G. T. 1930. A Comparison of the Hydrometer Method and the Pippete Method for making Mechanical analysis of Soils with new directions. Jour. Amer. Soc. Agron. 23: 747-751.
24. Bray, R. H. 1944. Soil test interpretation and fertilizer use. University of Illinois, Dept. of Agron., AG 1220.
25. Camp, A. F., H. D. Chapman, G. M. Bahrt, and E. R. Parker. 1941 Symptoms of citrus malnutrition. Chap. IX in Hunger Signs in Crops, Published by the Amer. Soc. Agron. and the National Fertilizer Assoc., Washington, D. C.
26. Census Office of the Philippine Islands. Census of the Philippines; 1918 I (1920) 630 pp. Bureau of Printing, Manila.

27. Census Office of the Philippine Islands. Census of the Philippines; 1939, Agriculture, Province of Misamis Oriental, Bull. No. 32-A (1940). Bureau of Printing, Manila.

28. Clark, N. 1940. Soil Erosion: Farmers and government together can whip it. Extension Service of College of Agriculture, the University of Wisconsin, Madison, Curcular 311. pp. 1-24

29. Duley, F. L. 1948. Stubble-Mulch Farming to Hold Soil and Water. U. S. Dept. of Agriculture. Farmer's Bull. No. 1997. pp. 1-32

30. Ellis, Carleton, and Miller W. Swaney. Soiless growth of plants. Reinhold Publishing Corp., New York (15th printing March 1946) 155.

31. Enlow, C. R. and G. W. Musgrave. 1938. Grass and other thick-growing vegetation in Erosion Control. Soils and Men. U. S. Dept. of Agriculture Yearbook 1938. pp. 615-633

32. Finch, Vernor C., and Glenn T. Trewartha. Elements of Geography (1936) 782 pp. Illus. McGraw-Hill Book Co., New York and London.

33. Foster, E. A. and H. A. Vogel. 1941. Cooperative Land Use Planning—A New Development in Democracy. U. S. Dept. of Agri. Yearbook Separate No. 1780

34. Hutchings, Irmi J. and Thomas L. Martin. 1933. Influence of the carbon-nitrogen ratios of organic matter on rate of decomposition in the soil. Jour. Amer. Soc. Agron. Vol. 26: No. 4 pp. 303-340.

35. Kell W. V. and R. McKer. 1936. Cover Crops For Soil Conservation. U. S. Dept. of Agri. Farmers' Bull. No. 1758. Revised 1842. pp. 1-14

36. Kellogg, Charles E. Soil Survey Manual. U.S. Dept. of Agri. Misc. Publ. No. 274 (1937) 136 pp.

37. Linsley, B. M. 1947. Methods of getting the job done on soil testing. Jour. Amer. Soc. Agron. 39: 294-299.

38. Locsin, Carlos L. 1950. Potash fertilization on sugar cane at Victorias, Negros Occidental. Jour. Soil Sci. Soc. Philippines 2: 105-108.

39. Locsin, Carlos L. 1950. Experimental work on sugar cane in Victorias 1948-1949 season, including part of 1950. Sugar News 26: 338-363.

40. Lopez, F. B. The Soil and Climate of Misamis Oriental in Relation to the Commercial Production of Abaca. Jour. of The Soil Soc. of the Phil. 1951 Vol. III No. 4. 264-271 pp.

41. Lyon, T. L., and H. O. Buckman. The Nature and Properties of Soils (1929) 428 pp. 33 figs. Macmillan Co., New York.

42. Madamba, A. L., and C. C. Hernandez. 1948. The effect of ammophos and lime on the yield of upland rice (Dumali) grown on Buenavista silt loam. Jour. Soil Sc. Soc. Philippines 1: 204-209.

43. Mamisao, J. P. 1949. Soil Conservation Problems in the Philippines, Journal of the Soil Science Society of the Philippines. Vol. I, No. 1, pp. 5-17

44. Marfori, R. T. 1939. Phosphorus studies on Philippine Soil, 1. The readily available phosphorus of soils as determined by the Truog method. The Philippine Journal of Science 70: 133-142.

45. Marfori, R. T., I. E. Villanueva and R. Samaniego. 1950. A critical study of the fertilizer requirements of lowland rice on some Philippine soil types. Jour. Soil Sci. Soc. Philippines: 155-172.

46. Mariano, J. A., F. B. Lopez, I. A. Romero. 1953. Soil Survey of Davao Province, Philippines, Department of Agriculture and Natural Resources, Soil Report 16.

47. Merrill, Elmer D. An Enumeration of Philippine Flowering Plants Bureau of Science Publ. No. 18 (1922-1926) 4 vols. Bureau of Printing, Manila.

48. Millar, C. E. and L. M. Turk. 1943. Fundamentals of Soil Science. John Wiley and Sons., Inc., New York.

49. Murphy, H. F. 1934. The replaceable potassium content compared with field response to potash fertilization of some Oklahoma soils. Jour. Amer. Soc. Agron. 26: 34-37.

50. Murray, William G. Farm Appraisal: Classification and Valuation of Farm Land and Buildings, 2nd ed., revised (1947) 73-82. The Iowa State College Press, Ames, Iowa.

51. National Fertilizer Association. 1948. The Third National Fertilizer Practice Survey (1944). The Fertilizer Review, 21, No. 1: 7-10.

52. Nichols, M. L. and T. B. Chambers, 1938. Mechanical measures of erosion control. Soils and Men. U.S. Dept. of Agriculture Yearbook 1938. pp. 646-665

53. Norman, A. G. 1947. The Yearbook of Agriculture for 1943-47. U. S. Department of Agriculture. Washington 25, D. C.

54. Norton, E. A. 1939. Soil Conservation Survey Handbook. U. S. Dept. of Agriculture. Miscellaneous Publication No. 352. pp. 1-40.

55. Parker, E. R. and Winston W. Jones 1950. Orange fruit sizes. California Agriculture 4, No. 3, 5 and 10.

56. Peech, Michael, and Leah English. 1944. Rapid micro-chemical soil test. Soil Science 57: 167-195.

57. Rola, Nena A., and N. L. Galvez. 1949. Effects of soil reaction on the growth of upland rice and on its nitrogen, calcium, phosphorus, and iron content. The Philippine Agriculturist 33: 120-125.

58. Rosell, D. Z. and A. S. Arguelles. Soil types and growth of algae in bangus fishponds. Phil. Jour. Sci. 61 No. 1 187-197.

59. Sherman, Henry C. 1939. Calcium and phosphorus requirements of human nutrition. U. S. Department of Agr. Yearbook 1939: 187-197.

60. Smith, G. F. and J. B. Hester. 1948. Calcium content of soils and fertilizer in relation to composition and nutritive value of plants. Soil Science 75. 117-128.

61. Smith, Warren D. Geology and Mineral Resources of the Philippines. Bur. Sci. Publ. 19 (1924) 559 pp. Buureau of Printing, Manila.

62. Soil Survey Staff; Bureau of Plant Industry, Soils and Agricultural Engineering. 1951. U. S. Dept. of Agriculture Handbook No. 18, pp. 251-325.

63. Spurway, C. H. 1939. A practical system of soil diagnosis. Mich. Agr. Expt. Sta. Tech. Bull. 132.

64. Spurway, C. H. 1941. Soil reaction (pH) preference of plants. Mich. Agr. Expt. Sta. Bull. 306.

65. Thatcher, Roscoe N. 1921. The Chemistry of Plant Life. McGraw-Hill Book Company, Inc. New York.

66. Tower, H. E. and H. H. Gandner, 1946. Strip Cropping for Conservation and Production. U.S. Dept. of Agriculture. Farmers' Bull. No. 1981. pp. 1-46

67. Truog, Emil. 1930. The determination of the readily available phosphorus of soils. Jour. Amer. Soc. Agron. 22: 874-882.

68. Truog, Emil. 1948. Lime in relation to availability of plant nutrients. Soil Science 65; 1-7.

69. United States Department of Agriculture. Soil and Men. Yearbook of Agriculture 1938 (1938) 948-1078. U.S. Government Printing Office. Washington, D.C.

70. United States Department of Agriculture. Climate and Men. Yearbook of Agriculture 1941 (1941) 265-291. U.S. Government Printing Office. Washington, D.C.

71. Walkley, A. and I. A. Black. 1934. Determination of organic matter in soils. Soil Science 37: 29-38.

72. Weir, Wilbert Walter. 1936. Soil Science, Its Principles and Practice. J. B. Lippincott Co., Chicago and Philidelphia.

73. Wonser, C. H., M. M. Striker, L. G. Bracheen, C. L. Mcintyre and Hoyt Sherard. Soil Survey: Lee County Alabama. U. S. Department of Agriculture. Series 1938 No. 23 (1950) 80 pp. U. S. Government Printing Office. Washington, D.C.

74. Zeasman, O. R. and J. W. Clerk. 1945. We Can All Help Save Our Soils Extension Service, College of Agriculture, University of Wisconsin, Madison. pp. 1-39