RESTRICTED

CIVIL AFFAIRS GUIDE

Agriculture in the Japanese Mandated Islands

OPNAV 13-17

OFFICE OF THE CHIEF OF NAVAL OPERATIONS
NAVY DEPARTMENT
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OPNAV 50E–2. Restricted, Military Government Handbook, *Kurile Islands.* 1 November 1943.

OPNAV 50E–3. (FM27–5.) Unclassified, *United States Army and Navy Manual of Military Government and Civil Affairs.* 22 December 1943.

OPNAV 50E–4. Restricted, Civil Affairs Handbook, *Administrative Organization and Personnel of the Japanese Mandated Islands.* 1 January 1944.

OPNAV 50E–5. Restricted, Civil Affairs Handbook, *East Caroline Islands.* 21 February 1944.

OPNAV 50E–7. Restricted, Civil Affairs Handbook, *West Caroline Islands.* 1 April 1944.

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OPNAV 50E–12. Restricted, Civil Affairs Handbook, *Taiwan (Formosa).* 15 June 1944.

OPNAV 50E–13. Restricted, Civil Affairs Handbook, *Taiwan (Formosa)—Economic Supplement.* 1 June 1944.

OPNAV 50E–14. Restricted, Civil Affairs Handbook, *Japanese Administrative Organization in Taiwan (Formosa).* 10 August 1944.

OPNAV 50E–15. Unclassified, Civil Affairs Studies, II. *The Languages of the Japanese Mandated Islands.* 20 June 1944.

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OPNAV 13-17

Prepared by
OFFICE OF FOREIGN AGRICULTURAL RELATIONS
DEPARTMENT OF AGRICULTURE
for
MILITARY GOVERNMENT SECTION
CENTRAL DIVISIONS
CHIEF OF NAVAL OPERATIONS

OFFICE OF THE CHIEF OF NAVAL OPERATIONS
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1 SEPTEMBER 1944

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LETTER OF PROMULGATION

OFFICE OF THE CHIEF OF NAVAL OPERATIONS,
NAVY DEPARTMENT.
WASHINGTON 25, D. C., 1 September 1944

CIVIL AFFAIRS GUIDE

AGRICULTURE IN THE JAPANESE MANDATED ISLANDS

OPNAV 13–17

1. OPNAV 13–17 is intended to provide useful information for civil affairs officers in the area indicated, but the material contained herein may be of value to other officers and for other purposes The suggestions contained herein are not to be construed as mandatory.

2. This publication is to be used and stowed in accordance with the provisions of U. S. Navy Regulations, Articles 75, 75½, and 76.

Vice Admiral, U. S. Navy,
Vice Chief of Naval Operations.

PREFACE

It is the primary purpose of this guide to point out and to analyze what appear to be the important agricultural problems with which civil affairs administrators in this area will have to deal, and to present in general terms alternative solutions to these problems for various circumstances. As a background for this analysis there is presented, first, a summary of important information related to the problems discussed. Details are available in the various civil affairs handbooks on the mandated islands.

The territory covered includes the Marshall Islands, the east and the west Caroline Islands, and the Marianas Islands. Guam also is included. While formerly under United States jurisdiction, and not a part of the mandated group, Guam cannot well be omitted in considering agricultural plans for the region as a whole.

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A. BACKGROUND INFORMATION

I. FACTORS AFFECTING AGRICULTURAL PRODUCTION

1. LAND AREA

Although scattered over an expanse which, east to west, is nearly as broad as the lower part of the United States, the total land surface of these islands is less than that of the State of Rhode Island.

Table 1.—Land areas

Island group	*Total area (approximate), square miles*
Marshall Islands	74
East Caroline Islands:	
Truk group	50
Ponape group	145
Kusaie	42
Others	13
	250
West Caroline Islands:	
Yap District	90
Palau District	185
	275
Marianas Islands (mandated):	
Saipan	71
Tinian	38
Rota	28
Others	110
	247
Guam (U. S. A.)	206
Grand total	1,052

2. POPULATION

In 1937, the total population of the mandated islands was reported to be 112,267, of which 61,323 were Japanese, 50,809 were natives, and 135 were of other nationalities. Of the Japanese population, nearly two-thirds resided in the mandated Marianas, where they were employed in connection with the sugar industry. Another large group lived in the western Carolines, where phosphate and other industries were developed. The native population of the Carolines and Marshalls was made up mainly of Carolinians, but there were a few Chamorros in the western and eastern Carolines. Of the natives living in the mandated Marianas, about three-fourths were Chamorros.

TABLE 2.—*Population, 1937*

	Mandated Marianas	Western Carolines	Eastern Carolines	Marshalls	Total
Japanese:					
Male	24,039				
Female	18,508				
Total	42,547	11,963	6,289	524	61,323
Natives:					
Male	2,137				
Female	2,008				
Total	4,145	12,306	24,259	10,099	50,809
Foreigners:					
Male	9				
Female	7				
Total	16	39	68	12	135
Total	46,708	24,308	30,616	10,635	112,267

The population of Guam, in 1940, was reported to be 22,290, of which 20,177 were Chamorros.

3. TOPOGRAPHY, GEOLOGY, AND SOILS

***a.* The Marshall Islands** are composed exclusively of coral atolls and single coral islands, which have been built up on submerged mountain peaks. Surfaces, therefore, do not have much elevation.

Soils are made up of sand, shells, and coral fragments, together with organic matter in varying amounts. Along beaches, the organic matter consists mainly of the remains of small quantities of leaves or of cast-up sea life. In the interior, organic matter often accumulates to a depth of some inches. Rapid chemical and bacteriological action, induced by high temperatures and abundant moisture, bring about changes in both organic and mineral material;

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consequently a certain amount of the essential nutrients is being constantly made available. Because of the heavy precipitation and the highly porous nature of the soil, however, leaching also is rapid. These soils are well suited to the growth of coconut palms, but they are poorly adapted to ordinary forms of cultivated agriculture. In reaction they are alkaline.

***b.* The eastern Carolines** are made up of: 19 coral atolls; 3 single coral islands; 2 volcanic islands (Ponape and Kusaie); and 1 complex atoll (Truk). The most important of these, from an agricultural point of view, is Ponape, which consists of a high main island, a number of small inshore islands, and an encircling reef. The main island is roughly circular in shape. It is deeply indented with bays and is about 13 miles in maximum diameter. The interior is reported to be exceedingly rugged and rendered nearly impenetrable by dense forests and the steep gorges of mountain streams. There are several peaks over 1,500 feet in elevation, the tallest reaching a height of 2,579 feet. The cultivated areas lie in valleys and in level areas inward from the coast.

Kusaie, the other important volcanic island of this group, is bisected by a transverse valley, which separates it into two unequal parts, a smaller northern portion dominated by a peak 1,911 feet high, and a larger southern portion culminating in Mount Crozier, 2,079 feet in elevation. The interior is of basalt formation, steep, rugged, and almost impenetrable. The Truk group consists of an enormous coral atoll, within which lie a cluster of high volcanic islands. Individually, these islands are much smaller in size than either Kusaie or Ponape. They are of basalt formation, and are rugged and forested, the peaks ranging from 200 to 1,483 feet in elevation.

The soils of these islands often include coralline elements along the shores (and on small coral islands) which are similar to soils on the Marshall Islands. On the major islands, however, soil is made up mainly of decomposed volcanic rock and humus. On steeper slopes the soil layer has often been removed through erosion; but the broader valleys and alluvial fans toward the coast contain some of the most fertile soil of the mandated area. Soils on Ponape are reported to be excellent in their supply of nitrogen, good in phosphoric acid, fair in calcium and magnesium, and deficient in potassium. A similar deficiency in potassium is reported from others of the volcanic islands, particularly from Palau; and potassium fertilizers are stated to increase yields greatly. A deficiency in available iron is also reported for certain soils.

***c.* The western Carolines** are made up of: 12 coral atolls, 9 single coral islands, and 2 complete atolls (Palau and Yap). The most important, agriculturally, is the Palau group, which consists of a complex cluster of volcanic islands, fragmented coral atolls, and islands of limestone composition, surrounded by encircling and detached reefs. The islands of this group reported to be of volcanic origin are Babelthuap, Arakabesan, Malakal, and probably Koror. Babelthuap, alone, accounts for more than three-fourths of the total land surface of the entire Palau group. It is about 23 miles long and varies from 4 to 8 miles in width, having a total area of about 143 square miles. There are several ranges of hills, the highest point having an elevation of 641 feet. The island is of volcanic origin, but some of the hills on the southern part of the island are chalk.

The Yap group is composed of 4 large and 10 small islands completely surrounded by a coral reef. Geologically the islands of the group differ from other islands of the mandated area in being composed of older crystalline rocks, with a foundation of sedimentary rocks. Rull, the largest island of this group, is about 10 miles long and has a maximum width of about 3 miles. It has a mountainous core, consisting of bare, brush-covered hills rising to an altitude of 820 to 984 feet, which occupies the entire northern half of the island. The southern half is a fertile plain, with extensive swamps in the interior and foothills toward the north. Tomil Island, which lies east of Rull, consists of a treeless central plateau surrounded by a low, fertile, wooded coastal strip from 1 to 3 miles wide.

The soils of these islands are similar to soils of the eastern Carolines, with the fertile areas being mainly confined to islands of the Yap and Palau groups.

***d.* The Marianas Islands** can be divided into two parts which have distinct differences in their topography and geological origin. The northern portion consists almost entirely of volcanic formations. Terrain is rugged, and many of the original volcanic cones are still evident. On several of these islands there are active volcanoes. They are virtually bare of soil suitable for agricultural purposes, except as it occurs in limited amounts in small valleys and along the coast.

Islands of the southern part of the Marianas include Saipan, Tinian, Rota, and Guam. These have developed from a core of volcanic rock at the base of which coral formations were deposited at some earlier period. With a later general rise of the land mass the accumulated deposit of limestone was raised well

above the sea level. This process, repeated several times, produced a series of terraces which now exist at different levels, with the original volcanic formations still appearing at some points on the island. On Saipan the highest point is 1,554 feet above sea level, while on Rota the highest peak is 1,612 feet.

The cultivated portions are confined largely to the limestone terraces. Subsoils may consist of coral limestone and sand, of decomposed volcanic rock, or of a reddish clay. Surface soils are a brown, loamy material, among which calcareous rocks are often interspersed. Although the depth and fertility vary greatly from island to island and within one island, in general the content of mineral nutrients is high and that of nitrogen is low. On Guam a deficiency in available iron is reported. In various places erosion has removed fertile layers and left the covering thin. Since they are generally porous these soils also suffer from drought during the dry season. A more fertile soil with heavier texture is found in much smaller amounts in stream valleys and on deltas at the mouths of streams, especially on Guam.

4. CLIMATE

***a.* Temperature.**—For the entire belt of islands which stretches from the Marshalls on the one side, to the western Carolines on the other, temperatures are high and extremely uniform throughout the year. Annual means range around 80° and 81° Fahrenheit; and monthly means vary only 1° or 2° from the annual means.

The single exception to this condition within the mandated area is found in the case of the Marianas Islands, where a larger difference between summer and winter temperatures is found. Annual means are also lower, that of Saipan being 2° or 3° lower than that of Palau or Ponape. Representative data appear in table 3.

TABLE 3.—*Representative temperature data*

Month	Saipan			Guam	Koror	Yap	Ponape	Truk	Jaluit	Ujeland
	Mean average	Mean daily maximum	Mean daily minimum							
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	76	81	72	79.0	80	80	80	81	80.8	80.0
February	76	81	72	.....	80	80	80	81	81.1	80.2
March	76	82	73	.....	81	81	82	80	81.0	80.7
April	78	83	74	81.2	82	82	80	81	80.8	81.2
May	78	84	74	.....	82	82	80	81	80.4	81.5
June	79	84	75	.....	81	82	79	81	80.6	81.8
July	79	83	74	81.0	80	82	79	80	80.4	81.7
August	79	84	75	.....	80	82	78	81	80.6	81.9
September	79	83	74	.....	81	82	78	81	80.5	81.7
October	79	83	75	80.5	81	82	79	81	80.9	81.6
November	79	83	75	.....	81	82	79	81	81.1	81.5
December	77	82	74	.....	80	81	80	81	80.8	80.9
Annual	78	83	74	.....	81	80	80	81	80.8	81.2

***b.* Precipitation.**—There are two general types of rainfall conditions. The first type is found in the southern part of the Marshall Islands, in the eastern Carolines, and in the western Carolines. Rainfall is heavy and is distributed rather uniformly throughout the year, the annual totals varying from about 120 inches to nearly 200 inches.

The second type is found to the north of this belt in the northern Marshalls and in the Marianas, where definite wet and dry seasons are found. On these islands rainfall is heaviest in the months of July to October inclusive, the months from January to April usually being dry. The total annual precipitation, on the average, ranges between 80 and 90 inches. Representative data appear in table 4.

***c.* Humidity.**—The relative humidity of most of this area is very high throughout the year, since there is great precipitation. Temperatures are high, too.

***d.* Storms.**—Destructive typhoons may be expected to occur sporadically throughout most of this area. In general, they appear to be less common in the Marshalls than elsewhere, though here also they are known. The effect on coconut and other trees may be extremely injurious. In the Marshalls southwest gales blow between August and November, sometimes with destructive force.

TABLE 4.—*Representative precipitation data*

Month	Saipan			Guam	Koror	Yap	Kusaie	Ponape	Truk	Jaluit	Ujeland
	Average	Extreme maximum	Extreme minimum								
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
January	5.6	18.4	0.6	2.4	15.0	6.5	13.7	13.2	7.2	10.2	2.1
February	3.4	11.2	.8	2.9	9.3	5.9	14.8	10.0	8.8	9.0	1.9
March	2.9	10.3	.8	3.2	6.8	5.0	18.0	10.6	8.4	14.3	2.7
April	2.4	7.6	.6	2.2	7.6	5.1	22.6	18.7	11.5	15.2	6.1
May	6.4	17.1	1.2	4.1	15.6	10.0	19.8	20.2	12.1	17.0	6.5
June	5.6	11.1	1.2	5.7	12.4	9.9	19.9	16.9	13.4	16.4	7.3
July	12.0	21.3	3.6	14.2	19.9	16.9	12.1	16.5	13.7	15.9	8.4
August	11.1	22.7	3.6	15.7	14.1	16.3	11.9	13.4	10.7	12.2	8.7
September	13.7	23.7	7.4	16.1	15.7	12.5	13.1	14.8	12.3	13.4	10.5
October	11.3	24.9	4.2	12.6	14.8	11.8	9.7	16.5	8.8	11.1	10.3
November	5.1	19.2	2.7	7.2	11.8	10.0	14.4	14.7	10.7	12.5	10.6
December	4.3	9.9	1.4	4.8	12.7	9.1	17.2	19.9	11.7	13.1	4.8
Annual	83.8			91.1	155.7	119.0	187.2	185.6	129.1	160.2	80.0

II. AGRICULTURAL PRODUCTION

1. BASIC CROP PATTERN

The crop pattern of these islands in former times was shaped entirely by local subsistence needs. Contact with Europe and with Japan, however, has introduced alterations. This has been seen to some extent in the growing of new kinds of food crops. But the more important changes have been evidenced in the development of several forms of commercial agriculture, which were designed to provide materials to fit into the economy of Japan rather than to raise the standard of living of the natives.

***a.* The Marshall Islands.**—The Marshall Islands retain the simplest of all the crop patterns. For local subsistence needs old-time crops, adapted to existing soil and climatic conditions, are still mainly relied upon. These include the coconut, breadfruit, taro, arrowroot, pandanus, and banana; but newly introduced vegetable and fruit items now are also raised. The principal form of commercial agriculture introduced is the raising of coconuts for copra production.

***b.* The Caroline Islands.**—In the Carolines, before the advent of Europeans, the staple food crops were breadfruit, coconut, and taro. These were supplemented by bananas, pandanus, arrowroot, yams and sweetpotatoes, and in some places by wild oranges, limes, and sugarcane. The relative importance of the different products varied on different islands, coconuts and taro usually assuming first place on coral atolls, and breadfruit on volcanic islands. This general pattern still forms the background of the native agriculture, but there have been new developments in commercial agriculture. Manioc, grown for starch, has become important on Ponape and Palau; truck gardening has been developed in the Ponape, Palau, and Yap districts; and a pineapple industry has been established in Palau. The production of copra also has been expanded.

***c.* The Marianas Islands.**—Agriculture on the mandated Marianas is dominated by the commercial production of sugarcane, which occupies over 60 percent of the total cultivated acreage of these islands. An appreciable acreage is also devoted to the growing of manioc; also coconuts are grown. For local consumption, considerable quantities of vegetables, melons, and tree fruits are produced; but rice is rare.

On Guam, corn, sweetpotatoes, yams, taro, and some rice form the basic foodstuffs grown for local consumption. Breadfruit is also grown extensively, but often is not utilized, the population preferring other foods. Pineapples, limes, tangerines, bananas, and papayas are the main fruits, and there is a great variety of vegetables. Copra production is the most important enterprise in commercial agriculture.

Acreage and production of the principal crops, in 1937, are summarized in table 5.

2. EXPERIMENT STATIONS

An agricultural experiment station was first established on Ponape by the Germans. Under the Japanese, in 1922, a head industrial experiment station was established on Palau, on the east end of Koror, under the Tropical Industries Research Institute. A branch station was later established on Ponape. Also, in 1930, one was established near Magicienne Bay on Saipan. The Nanyo Boeki Kaisha maintained an agricultural experiment station on Pagan in the Marianas, on which vegetables, sugarcane, and cotton were grown experimentally. And on Yap there was a demonstration farm where students were given train-

TABLE 5.—*Reported acreage and production of principal crops, excluding coconuts, 1937*

Crops	Ponape district		Truk district		Yap district		Palau district		Saipan district	
	Area	Volume	Area	Volume	Area	Volume	Area	Volume	Area	Volume
	Acres	*Short tons*	*Acres*	*Short tons*	*Acres*	*Short tons*	*Acres*	*Short tons*	*Acres*	*Short tons*
Cereals	72	43	3			1	5	2	326	74
Legumes			3	9			5	7	178	47
Sweet potatoes	62	276	7	28	724	959	353	653	778	910
Vegetables:										
Yams	264	874			67	48	12	6	86	116
Taro	217	579	603	918	734	257	781	2,615	151	476
Manioc	1,285	11,177			7	34	902	5,172	3,620	12,576
Other vegetables	96	134	44	129	20	117	235	629	1,322	6,216
Fruits:										
Pineapples	35	9	17	38	7	27	991	1,263	35	21
Bananas	210	585	17	79	7	7	126	296	193	227
Breadfruit	1,038	4,744	7,574	15,331	168	109	27	2		
Mandarin oranges	10	2			22	8	67	21	25	14
Others	47	104		4	12	3	94	484	951	201
Technical crops:										
Sugarcane	3	55					20	32	28,355	583,180
Cotton	32	13			15	3			247	32
Coffee	7						7	1	492	290
Miscellaneous							44	1	143	7
Total	3,378		8,265		1,783		3,669		36,902	

ing. Model farms were also operated on Truk, at other locations on Ponape, and possibly elsewhere.

The subjects investigated in these experiment stations included agriculture, horticulture, animal husbandry, and dendrology. Considerable attention was given to the introduction and testing of new varieties of plants. Extensive hybridization work with rice was reported at the Ponape station, with the object of finding a rice of suitable quality which could be handled under the humid conditions prevailing there at harvest time. On Palau special investigations have been made with crops which include upland rice, sweetpotatoes, pineapples, millet, beans, peanuts, taro, tobacco, coffee, cotton, papayas bananas, tangerines, coconuts, peas, and cabbage.

Attention at all stations has been given to the control of insect pests, and to experiments with fertilizers. The introduction of new breeds of livestock, and crossbreeding experiments with native types, has also been undertaken.

It can be assumed that, as a result of these efforts, a store of knowledge has been accumulated which could be of immense value to anybody who has to deal with the agricultural problems of this region. Successes and failures would be of equal importance. It is to be considered highly desirable, therefore, that competent personnel be on hand as quickly as possible after these islands are occupied, to collect and preserve whatever records, equipment and plant or animal material may have escaped destruction. In this material may be found solutions to problems which otherwise could be solved only after years of research.

FIGURE 1.—Ponape Island. Terrain showing rugged interior and isolated patches of cultivated land along coastal fringe (1944).

602563—44 (Face p. 7) No. 1

FIGURE 3.—Palau Islands. Koror Island, with settlement and cultivated fields, and smaller

502563—44 (Face p. 7) No. 2

FIGURE 4.—Ponape Island. Cultivated area southeast of Ponape town on Tawenjokola River, with

islands with typical rough terrain (1944).

arts of surrounding land in coconut palms (1944).

Crops	Diseases and injurious insects	Methods of extermination and prevention
Japanese taro	Taro plague	The places where mixtures of predominantly potash were used showed best results (e. g., 3.2 kan of nitrate, 2.224 kan of phosphate, and 6.84 kan of potash). Where phosphate mixed with lime was used, showed next best results.
Cucumber	*Udonko* (powdery mildew) and *Beto*.	Sugar-Bordeaux mixture has considerable effects, but there is danger of incurring ants and plant-lice.
Tobacco	Brown spots	3-To? Sugar-Bordeaux mixture is the best.
Coconut	Round shell insect (Engai karamushi).	A mixture is Riley No. 1 and pine resin is the best, and a mixture of pyrethrum (Vermifuge chrysanthemum), lime and sulphur is next.
Orange croton, breadfruit.	Shell insect (*Mensui kai karamushi*).	A mixture of one part Riley No. 1 and pine resin with 5 parts of water; and a mixture of Riley No. 2 and pine resin without water, are the best.
Tapioca, sweet potato, cotton.	Shell insect (Watakatakai garamushi).	A mixture of Riley No. 1 and pine resin; a mixture of one (?) Riley diluted with 5 parts of water and pine resin without water; a mixture of Kuwana or Somei, and pine resin with water are the best. Riley No. 1 and No. 2 are drugs and considered injurious.
Melon group	Uriwa insect	Derris Bordeaux mixture (Derris powder 20 momme, 2 *go* and 6 *momme* of solution and 1 *to* 7 Shikido soap) is the best.
Agricultural crops and lumber.	Egypt mensui-shell	Betaria Lady bird (Lady bug) is the best. Damages by Mensui shell insects were great in the South Sea Islands, but since having brought this Lady bird from Japan and transplanted it in Palau, Yap, Saipan, Truk where most damages were inflicted, the noxious insects were exterminated within a short period.
Radish	Radish Haimadaramega.	Derris soap and Imatsu Insecticide are the best.
Melon group	Melon Larva	Nicotine solution (750 grams of fine cut tobacco, 150 grams of dissolved lime, and 20 liter? of water) is the best.
Tobacco	Striped Green Caterpillar.	Kuishita arsenate of lead and arsenate of copper are the best.

Berereu is the most superior and *Mariano*, *Carolinas*, and *Ariman-abakka* come next. From the standpoint of quantity of starch, *Carolinas* and *Kekerazu* are most superior, exceeding 130 kan of starch per ton of root.

By using such fertilizers as nitrate and potash, the starch content is greatly increased. Especially, 1 month before harvest when it does not rain much, the yield of roots and the quantity of starch in them are greatly increased. The best harvest season is the full flowering time. As for methods of storing, it is best to bury the roots under the ground for improvement of quality; however, this reduces the starch content. At present, industrial experimentation is under way with the Ikeda Starch Manufacturing Machine.

An experiment has been conducted in canning pineapple, comparing the native variety with the Sumu sukaien (Smooth Cayenne?) variety. The latter (Smooth Cayenne) has the advantage of attaining the first grade without use of much labor in processing; but it requires a great deal of sugar, and is of poor color, as well as being very fibrous. The former native easily breaks when cutting and requires a great deal of labor, but it is sweet, does not require much sugar, its color is very good, and it is not fibrous.

Another experiment has been conducted on degrees of ripeness, classifying the fruit under three categories by color-ripeness, the half-ripe yellow, the dead-ripe yellow, and the barely-yellow fruit. The half-ripened pineapple is found best. In the manufacture of sugar syrup the best way to make it is of white sugar, in a double pot at low temperature. Crystallized sugar gives a dirty color, not to say a variable result in the syrup product. When syrup is made in an ordinary pot, the sugar turns brown and it has taken on an odor. An experiment has also been conducted to determine lengths of time required to kill germs with heat: trying 40, 30, 20, 10, and 8 minutes, the observation was that 8 minutes was the best. At present under investigation is the question of the degrees of decomposition.

3. *Geological investigation.*—Geological experimental projects are being carried out in Saipan, Palau, and Ponape to improve land for cultivation of crops by examining physical and chemical characteristics of arable and unclaimed lands in the South Sea Islands.

4. *Fertilizer experiment.*—Land power is exhausted in degrees according to different crops. The following table indicates the percentage of yield, taking the first year's yield as 100.

Land of the Industrial Experimental Station is lacking nitrate, phosphate, and especially potash.

The result of fertilizer experiments

Year	Sugar-cane	Arrow-root	Sweet-potato	Tobacco	Corn	Cotton	Pea	Dryland rice	Peanut	Tapioca	Kaoliang (sorghum)
First	100	100	100	100	100	100	100	100	100	100	100
Second	31	31	44	...	...	...	...	...	42	55	...
	61	52	71	...	...	...	...	...	20	50	...
Third	39	58	...	103	...	...	...	120	18	87	...
	27	93	56	70	...	...	...	355	29	96	...
Fourth	11	41	2	...	...	...	...	...	79	37	...
	20	39	1	...	...	...	16	...	...	43	...
Fifth	8	33	...	...	...	...	...	...	3	26	...
	14	36	...	...	...	...	...	...	5	29	...
Sixth	20	29	...	...	...	...	...	...	...	1	...
	10	11	...	...	...	...	...	...	...	1	...

NOTE.—Upper figure is the percentage of yield as result of *continuation of crops* (first year is 100 percent). Lower figure is the percentage of yield as result of *rotation of crops* (first year is 100 percent).

Therefore, when potash is used, the result is quite noticeable. The suitable amounts for the various crops are as follows:

Fertilizer	Dried rice	Sweet-potato	Tapioca
	Kan[1]	*Kan*[1]	*Kan*[1]
Nitrate	2	2	1
Phosphate	1½	½	1½
Potash	2½	2½	1½

[1] 1 kan is 8.27 pounds.

Although the degree of erosion caused by cultivation corresponds to 500 or 600 *kan* of organic matter each year, in reality, on account of rain, a very considerable amount of organic matter is necessary in order to maintain a suitable degree of vitality in the soil.

Green manure such as Kuratarariya, Sutoriata, produce a great amount of organic matter and nitrate, and Tefuroshia Kandeita comes next. "Field turnip" (Ta-Kabura) and coffee grow quickly and are convenient to handle, but their resistance to drought is weak and they produce very little nitrate and organic matter. The best harvesting season, as in Japan, is at the full flowering time.

Frequent rain in the South Sea Islands washes salt out of the earth which, lacking the basic group, becomes colloidal. For this earth, lime becomes the direct nourishment for the crops, improves it physically and chemically, and promotes bacterial activity. Therefore, its effect is great.

5. *Experiments in prevention of diseases and noxious insects.*—Investigations have been conducted into the kinds and distribution of diseases and noxious insects, and on conditions of their parasites and natural insect and germ enemies. Experiments in their extermination and prevention have also been conducted with good results.

Among the above mixtures, Bordeaux mixture (3 kinds of 2, 3, 4 to types) was used twice at 3 p. m. and 1 hour before sunset on a clear day, but except in the case of cucumbers it did not inflict any damage on the crops. For prevention of diseases and insects, raw-lime, "Kazein" lime, "Zerachin" are also very good. One-year-old South Sea Island-grown derris root has more insecticidal than that of Singapore, Sumatra, Java, and Bonin.

6. *Manufacturing experiments of agricultural products.*—Since 1928, experiments on tapioca starch manufacture and pineapple-canning manufacture have been instituted. Starch in the tapioca root runs from 19.6 to 26.5 percent. Of the several varieties,

APPENDIX I. REPORT OF THE INDUSTRIAL EXPERIMENT STATION OF PALAU

[Translated from *Section 9: The Industrial Experimental Station*, (p. 372 ff.). South Seas Government. *Nanyo-cho shiesei junen-shi* (History of Ten Years of Administration of the South Seas Government, 476 pp., Tokyo, 1932]

Results of experiments and investigations conducted since establishment of the Industrial Experimental Station, Palau, are as follows:

A. THE AGRICULTURAL DEPARTMENT OF THE MAIN STATION

1. *Experiments as to fitness and variety.*—According to experiments and investigations on various tropical crops, the superior variety in each case has been found to be as follows:

Classification	*Superior variety*
Dried rice	Yap nonglutinous rice, hakumai hari (white rice needle).
Indian millet	Red flint Indian millet.
Corn	White Menado, White Dent Corn.
Millet	Tamashiro, Hanroppyo (lit-half-6-bushels).
Bean	Kederei No. 16, Aochi (lit-blue ground).
Pea	Okinawa.
Cassava	Kekerazu, Son. (Keckler's "sun").
Sweetpotato	Red skin, Fukushima.
Taro	Hachijo-shima.
Cotton	King's Improved.
Tobacco	Bright Yellow, Manila No. 1, Oita.
Peanut	Baranippa big grain, Java big grain.
Green manure	Kurotarariya, Tefuroshiya, Taao.
Eggplant	Mansaisensei, Yahara.
Squash	Hubbard, Shukumen.
Cucumber	Seidai, Long green.
White muskmelon	Tokyo hase, Takada.
Watermelon	Yamato, Kanro, Improved Florida.
Turnip	Tokyo daicho.
Radish	Shogoin, Horyo.
Chinese cabbage	Korean cabbage, Shantung cabbage.
Green onion	Senjutai, Sapporo deep root.
Vegetable pea	Reisei.

Besides the above, there are also the following promising crops:

Classification	*Superior variety*
Foods	Mango, Breadfruit, "Baramitsu," 'Saogaki," Orange, Lemon, Papaya, Pineapple, Banana, Yam.
Fibers	Hemp, Indian mallow, sisal hemp.
Starches	Arrowroot, Taro.
Spices	Ginger, pepper, cinnamon.
Oils	Caster oil plant.
Drugs	Coca.

2. *Experiments in cultivation.*—Result of experiment and investigation are as follows:

Item	Experiment	Observation
Dry-land rice	Quantity of seed	2 or 3 sho per tan found optimum quantity (i. e., 0.4 to 0.6 bushels per acre).
	Width of ridges	A narrow ridge is rather better than a wide one: 1.5 to 2 shaku is good (i. e., 1½ to 2 feet).
Sweetpotato	Ridges	Flat ridges are better for yield.
	Length of seedling	Long seedling is better for yield.
	Harvesting season	For Fukushima a period of 7 months is best, because a period shorter than 5 months is too short for full yield, and a period longer than 7 months is subject to the danger of rat and insect damage.
	Depth of plow	The deeper the better, but not so deep as to touch the bottom ground. Shallow plowing invites the dangers of a small yield and damage by rats.
	Number of times for turning vines over.	Although it is not generally done, it does improve the roots' quality. There is not much difference in yield.
	Comparison of the cultivation methods.	Yield is much greater in Japan than in the South Sea Islands.
Tapioca	Length of the seedling	About 1 shaku (1 foot) is good.
	The part of seedling inserted.	The bottom of the main stem.
	Methods of inserting seedlings.	Straight inserting is better for yield, and water-level planting is the best.
	Distance between stumps.	About 3 shaku is the best for yield.
	Harvesting season	2 months after flowering time, or 7 or 8 months after planting is best.
Arrowroot	Methods of ridges	Ditch system is best, and flat ridge is the next.
	Methods of seedling	The center part is best for more yield.
	Size of seedling	The large ones are the better.
Pea	Width of ridges	Both Okinawa pea and green pea are good to be planted in 1.5 shaku.
	Distance between plants	For Okinawa pea 0.8, and green pea 0.6 shaku.
Indian corn	Width of ridges	There would not be much difference in case of certain seeds.
Peanut	Harvesting season	For Baranippa 165 days after germination is best for yield and quality.

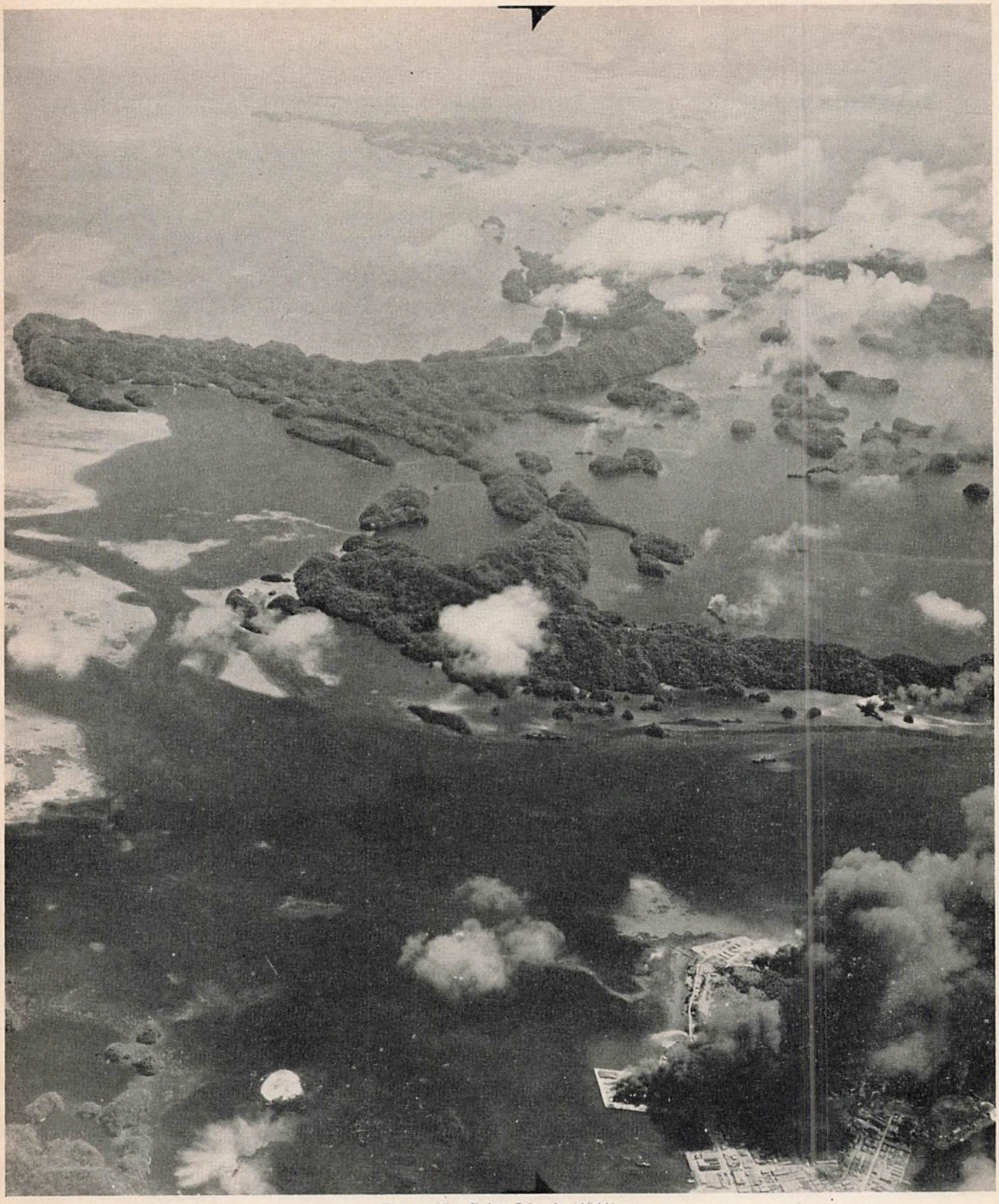


FIGURE 27.—Palau Islands (1944).

FIGURE 25.—Palau Islands, Angaur Island. Phosphate refinery, storage buildings and loading installations (1944).

FIGURE 26.—Palau Islands, Peleliu Island. Phosphate refinery and loading pier (1944).

sumed will be damaged or destroyed. In the final decision, in case Nauru is by then reoccupied, probably it would be advisable to take into account the advantages to be gained by the application of effort in reopening mines on the mandated islands as compared with what might be gained by applying a similar amount of effort on islands nearer the consuming countries.

Should a consideration of pertinent factors suggest that steps toward reopening the mines might be taken, qualified engineers expert in this kind of mining could form an appraisal of the situation and make estimates as to what would be required to establish production on a desired scale.

c. **Stranded labor.**—The occupation of the western Carolines might find laborers formerly employed in these mines stranded there. These may number from 300 to a maximum of 700. Presumably most of them would be anxious to return to their homes, but they might be available for ordinary forms of labor.

is another loading pier on the northeastern side of the island.

Recent reports suggest, also, that loading facilities of some description have been installed on Peleliu Island. Details of their nature, however, are lacking.

***d.* Labor.**—In the western Carolines, the Japanese recruited native labor to work the phosphate mines. A relatively small number of Chamorros were employed in jobs requiring skill, or as supervisors. The great majority employed, however, were natives of the Carolines. In recent years, about half of these, it is reported, came from the Palau and the Yap districts, but nearly half came from the Truk district. Actual recruiting was done by the chiefs, who received commissions. Verbal contracts were made, usually on a 1-year basis. Chamorros were allowed to bring their wives, and employees of this class became more or less permanent. Carolinians were not allowed to bring wives, and they often returned to their homes at the end of a year. Official figures state that in 1937, 388 natives in the Palau district were classified as miners; but another source states that in 1936, about 700 natives were engaged in mining in the western Carolines.

***e.* Current phosphate situation.**—Although the current situation with respect to phosphates is relatively satisfactory in the United States, acute shortages have developed in Australia and New Zealand since the output of Nauru was lost. Phosphate rock obtained from that source between 1938 and 1940 amounted to an annual total of between 800,000 and 1,000,000 short tons. Since this constituted a very large proportion of all the phosphate rock imported into Australia and New Zealand, its loss has caused a serious deficiency not yet made up from supplies obtained elsewhere.

The shortage will, no doubt, be somewhat relieved when Nauru is retaken, but serious damage to the loading and mining installations by bombing will reduce output until restoration has been effected.

***f.* Effect of the war on phosphate industry of Mandated Islands.**—Probably it may be assumed that by the time these islands have been occupied, mining and loading installations will have been damaged, possibly destroyed. Parts most likely to be affected are storage and refining plants on any or all of the main producing islands, but particularly the loading facilities on Angaur.

3. ALTERNATIVE COURSES OF ACTION

***a.* Local use of unprocessed phosphate material.**—Guano is a fertilizer, originating in bird droppings and the bodies of dead birds, which is rich in readily available phosphorus and containing varying quantities of nitrogen. It is found in locations where large flocks of birds have roosted, and it consists of a loose material, some of which continues to release a certain amount of ammonia.

Where deposits of this material are found in easily accessible locations, they could serve as good sources of a phosphate fertilizer for vegetables, fruits, and other crops. It has a phosphorus pentoxide content of approximately 10 per cent and a nitrogen content varying from almost nothing to 10 per cent. In the absence of other fertilizers, this alone would be a valuable fertilizer on soils of any of these islands, applied at the rate of about 800 pounds an acre. Applied at the rate of about 400 pounds an acre and supplemented with 100 pounds of ammonium sulphate and 200 pounds of potassium sulphate, a good complete fertilizer would be provided. The difficulty in handling it, however, suggests that it not be considered if shipping permits the use of the other fertilizers recommended.

Phosphate rock is seldom recommended for use without chemical treatment, by which it is made into the widely used superphosphate. The powdery material might be considered for use without processing under certain circumstances. In no case would applications of this material be expected to produce as good results as would be obtained from equal quantities of superphosphate. On calcareous soils, such as are found in the Marianas and on coral islands of other groups, it would have little or no value. It may be worth consideration for use on acid or neutral soils, which may be found on Kusaie, Ponape, Truk, Yap, and Palau. On these soils its use at the rate of about 800 pounds an acre should be of some benefit. Where superphosphate can be imported, however, that material is to be preferred.

***b.* Reopening of mines.**—If the present shortage of phosphates in Australia and New Zealand continues after the mandated islands are retaken, the islands probably ought to be investigated for the possibility of supplying phosphate material to those countries. While the total reported output of the mandated islands in 1939 was only about one-fourth of what Australia and New Zealand imported from Nauru, even half the former output might be of substantial benefit. Labor presumably would not present a serious problem, since the sources used by the Japanese should still be available. There might be a question whether shipping could be supplied. There would be additional problems involved in the supply of technical and managerial personnel, and in the replacement of equipment which it is pre-

will be economically practicable and which will contribute to the welfare of the people. The high yield of manioc on Ponape suggests that a starch industry on that island might be profitable. Rough forms of sugar might be produced on most of these islands for local consumption to reduce the imports. On Palau, there are phosphates that could be exported; and pineapples have been grown there on a commercial scale. On the Marianas, coffee and fruit offer additional opportunities. Although few data are available on the subject, the production of certain fiber crops, such as hemp, jute, and sisal for bags and rope might also be considered.

The extent to which the natives would benefit by the establishment of such industries, of course, would depend upon the extent to which they were able and willing to participate. Nevertheless, these forms of industry offer possibilities of providing exportable material.

VI. PHOSPHATES

1. THE PROBLEM

Although phosphates are not an agricultural product, the close relation which they bear to agriculture warrants a consideration in this guide of problems connected with the phosphate deposits of the mandated islands. The important questions involved appear to be: (1) The extent to which the material of these deposits can be utilized without further processing, as a phosphate fertilizer within the area; and (2) the extent to which these deposits can be utilized in meeting current shortages of phosphates elsewhere.

2. THE SITUATION

***a.* Location and production of phosphate material.**—Deposits of guano are reported to exist on Bikar, of the Marshall Islands; and small quantities of phosphate rock are mined on Ebon, of the same group, as well as on Tafwensak in Kusaie of the East Carolines. In the Marianas, loose deposits of guano are reported on Maug and Medinilla; and other phosphate deposits are found on Agrihan, Medinilla, Rota, Saipan, and Tinian. The largest deposits, however, appear to be in the West Carolines, particularly on Angaur Island, which accounted for about half of the total production of the mandates during 1938 and 1939. Available data on the total reserve supplies are scanty; but it is generally estimated that the total on all islands is somewhere between 3 and 4 million tons of high-grade rock. The reserves of low-grade material are thought to be about double this figure.

Reported production during recent years, almost entirely absorbed within the Japanese Empire, is shown in the following table:

TABLE 12.—*Reported production of phosphate material, 1935–39*

[In short tons]

Origin	1935	1936	1937	1938	1939
Angaur Island	86,103	98,354	100,595	114,844	158,092
Fais Island				15,677	48,304
Gaferut Island				823	
Peleliu Island	6,103	24,414	30,871	31,488	28,994
Rota Island			10,829	54,800	47,993
Saipan Island				6,109	22,794
Tobi Island			1,551	3,097	4,706
Total	92,206	122,768	143,846	226,838	310,883

SOURCE: Compiled from The Phosphate Exports Association, New York, reported in K. D. Jacob's "Phosphate Resources of Japan," Special Report No. 6, United States Department of Agriculture, Division of Soils and Fertilizer Investigations, Bureau of Plant Industry, Soils and Agricultural Engineering, Sept. 22, 1943.

***b.* Nature of deposits.**—It is reported that all of these deposits originated from guano, deposited by birds long ago. In the course of time the phosphorus contained in the material dissolved in rainfall, was carried downward where it combined chemically with the calcium carbonate of the limestone rock below. There is often present, however, powdery remains of the original guano in which, also, the phosphorus has combined to a greater or less degree with calcium carbonate. The phosphorus contained in the powdery material is not as readily available to plants as that in guano, but it is considered to be somewhat more readily available than that of phosphate in the rock form. There is no record of the relative amounts of these two types. The content of phosphorus pentoxide of the better materials is stated to be as high as 39 percent.

***c.* Installations for shipping.**—It is known that rather extensive facilities for loading have been installed on Angaur Island. The phosphate powder is shoveled directly from the mine into small dump-carts, which run to the anchorage on portable tracks. There are estimated to be about 12 miles of phosphate railroad on the island. The refinery and storehouse are located at Saipan village, on the western coast of the island. After being taken there, the material first passes through some kind of a refining process. Then it is brought out on a conveyor belt to a large automatic loading arm extending over the anchorage, where it drops through a rubber tube into the hold of the ship taking on cargo. The loading capacity is about 3,500 tons a day. Reports indicate that there

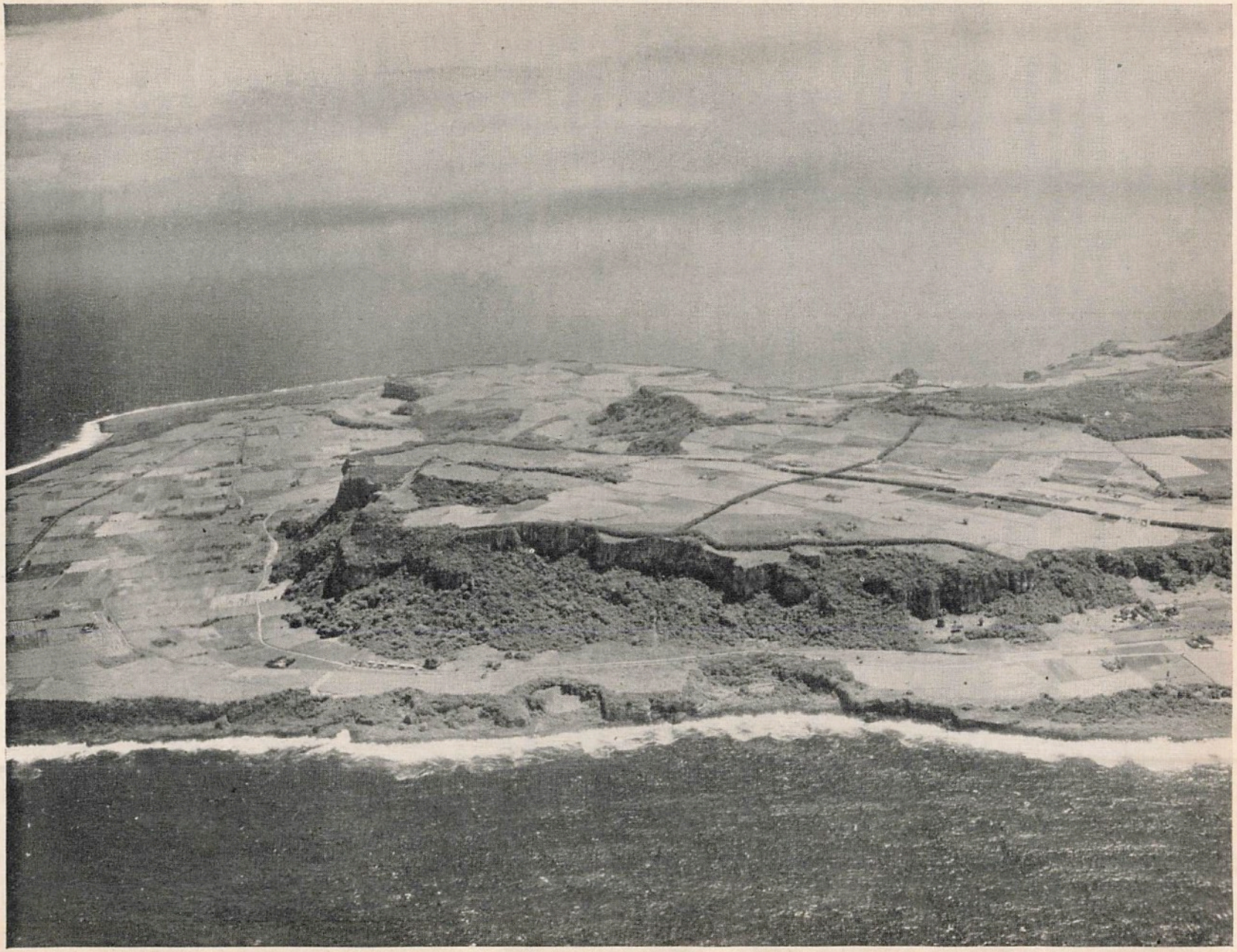


FIGURE 24.—Saipan. Canefields (1944).

grows poorly or not at all on Ailuk, Eniwetok, Jaluit, Likiep, Pokaakku, and Utirik; and these islands imported this product from other islands having a surplus, namely Ailinginae, Arno, Majuro, Maloelap, and especially Mejit. It is probable that there were other instances where interisland exchanges of foodstuffs were made, although no record of them has been observed.

***d.* Effect of the war on production of foodstuffs.**—The temporary loss of a market for copra has already been mentioned. One effect of this loss of market, in certain places, has been to increase the dependence of natives on the types of foodstuffs which traditionally formed the main items of diet. Where extensive military operations have destroyed coconut and breadfruit trees and land in other crops, of course the food supply has been reduced or even eliminated. And the local food supply of natives will probably be affected where land under cultivation has been requisitioned for the construction of military installations, or where the strategy requires that native populations be removed temporarily.

3. ALTERNATIVE COURSES OF ACTION

***a.* Rehabilitation of native agriculture.**—Since the native economy is dependent to such a great extent on the sale of copra, the rehabilitation of coconut plantations may be desirable from the long-range point of view. Procedures have already been discussed in Section I, Coconuts and Copra Production. The rehabilitation of breadfruit plantings is also a matter of importance from the standpoint of food. The breadfruit tree requires good soil, and trees are usually planted in the interior. They may be grown from seed or from shoots. Where precipitation is ample, the fruit ripens throughout the year. In the northern portion of the Marshall Islands, where part of the year is dry, breadfruit matures from July to September.

Neither coconut nor breadfruit trees, however, will mature soon enough to affect the supply of foodstuffs during the next few years. To supply basic edible products in the shortest possible time, therefore, it seems important to urge the planting of such crops as taro, arrowroot, yams, sweetpotatoes, and vegetables, which will mature quickly.

The method of handling these crops is well understood by the natives of the different islands. Their assistance, therefore, should be solicited. The taro is less important on the Marshall Islands, where its cultivation is mostly confined to marshy lands of the interior, but on many islands it is of major importance. Commonly there are types which grow on well-drained land as well as those which thrive in marshes. This crop yields at all seasons, but planting is usually done at specified seasons. On Truk it is planted in the spring. On Guam it is planted during the summer rainy season. Small suckers which spring up from the roots, the crown of the plant, or the tuber itself may be used for propagation. Stock from other islands may be used where planting material is lacking; and varieties from Hawaii are said to do better in Guam than the varieties which are native there.

For most of the other crops mentioned, both planting and harvesting is done at any season of the year when rainfall is favorable. Pandanus is best propagated from root shoots, since plants that develop from seed may be of wild types. Arrowroot is usually grown from small tubers, which are commonly left in the ground when the large tubers are harvested. Yams are cut up and the pieces planted in hills.

***b.* Long-range considerations.**—The agriculture of this area without doubt will continue to have two aspects: one, subsistence agriculture, for the production of foodstuffs the natives themselves consume; and, two, commercial agriculture, to grow crops for sale or exchange. For subsistence, probably old types of food crops will continue to be important, particularly on the coral islands where it is difficult to raise others. But the increasing demand for rice suggests that efforts to increase the domestic production of this crop ought to be considered. The successful production of small quantities of paddy rice on Ponape and Palau in the past suggests that more could be grown on those islands although it might be difficult to arouse the interest of natives. Reference to dry-land rice in the Western Carolines suggests that it might be possible to increase production of this type of rice in that area. The production of rice in the Marianas has already been discussed. On Guam, appreciable quantities of paddy rice have been produced, but efforts to increase its production met with only partial success because imported rice was cheaper.

Unless action is taken to produce rice locally, however, there is danger that the import of this commodity may result in an unbalanced economy, with imports exceeding exports. A planned control of imports might be desirable, to establish a balance between amounts imported and ability to pay for them. Or, if this course is not desirable, an increase in copra export might provide a partial solution.

Involved here is the question of replacing certain more or less uneconomic industries, established to supply items to Japan, with other industries which

the event that such an interest does develop, it may be well to point out that the production of improved types of livestock is generally a matter for specialists to handle. If previous experimentation makes clear the course which should be followed, quantity production might be achieved within a year or two. If further experimentation is necessary, the time involved would be much longer. In either case, it would probably be unwise to proceed without advice from a qualified animal-husbandry specialist. Considering the importance of parasites and diseases, a veterinarian would also be important. If the selection of such types of personnel is to be considered, those who have had experience under tropical conditions would be especially useful.

V. NATIVE AGRICULTURE AND FOOD SUPPLY

1. THE PROBLEM

Immediate problems in food supply as well as long-range considerations with regard to native welfare are, in no small degree, bound up with agriculture. Their solution must also, to a large extent, be sought in planned agricultural procedures.

2. THE SITUATION

***a.* Native diets.**—In former times the diet of the natives of this area, although differing in different locations, followed one general pattern. The base of an ordinary meal was always a starch dish, to which was added grated coconut, coconut milk, or bananas for sweetening. The starch dish may have been breadfruit, particularly on those islands where it grows abundantly. Otherwise it may have consisted of taro, yams, sweetpotatoes, or arrowroot. Fish and shellfish were important supplementary foods consumed almost daily. Tortoises were a luxury. Pork came into the diet later, but particularly as a dish for festival occasions. And fruits, vegetables, and nuts were used in certain places, particularly in the western Carolines.

While this basic pattern has been maintained in recent years, the items have changed to some extent. Instead of the old starches, rice, corn, and flour are often preferred. Tinned fish and tinned meats, and a wider variety of fresh meats including pork, chicken, pigeon or beef, are also being used. Furthermore, there are new vegetables, including cucumbers, melons, pumpkins, and eggplant. The extent of the change is greater on some islands than on others, the change, in general, having been least in the Marshall Islands and most in Guam and the mandated Marianas. On Guam, breadfruit and taro are often allowed to go unused, rice and wheat flour being purchased instead. More fresh meats, eggs, and fruit also seem to be consumed. On the mandated Marianas, the natives are particularly fond of tinned salmon; and it is said that, for sweetening, they would rather have commercially prepared jam or jelly than their native fruits.

***b.* Imported foodstuffs.**—Data on the total amounts of certain foodstuffs imported prior to the war are available, but in most cases there is no way of telling what proportion was consumed by the Japanese and what by the natives. In the case of rice, however, a rough estimate is possible, assuming that the average per-capita consumption by Japanese in the mandated islands is about the same as in Japan. That figure is approximately 350 pounds a year. A calculation made strictly on this basis becomes questionable, however, because import figures are not available over a period of years. Also, it is not certain that the imported quantities were consumed entirely by the civilian population. On Guam the average per capita "disappearance" in 1940 is calculated to have been approximately 200 pounds. Taking all these factors into account, the figures in table 11 show amounts estimated roughly to represent consumption of rice by the natives in 1937.

TABLE 11.—*Estimated consumption of rice by native peoples, in 1937*

Name of islands	Native population	Probable per-capita consumption	Estimated total consumption
		Pounds	*Pounds*
Marianas	4,145	175	725,375
West Carolines	12,188	100	1,218,800
East Carolines	23,248	50	1,162,400
Marshalls	10,131	50	506,550
Total	49,712		3,613,125

Of the 4.5 million pounds consumed in Guam in 1940 about 4 million pounds were imported. Therefore, prior to the war, total imports of rice for consumption by native peoples for the mandated islands plus Guam are estimated to have been somewhere between 7 and 8 million pounds.

The amounts consumed by native populations of other foodstuffs, such as wheat flour and canned fish, are not easily calculated. Although the natives ate some, it may be assumed that the major part of these items was consumed by Japanese.

***c.* Interisland exchange of foodstuffs.**—In the Marshall Islands it is reported that a certain amount of breadfruit was ordinarily shipped from surplus to deficit areas. According to these reports, breadfruit

most countries of the temperate zone, but it is hardly able to survive in tropical environments; and the same is true of many of the popular breeds of our common forms of productive livestock. In addition, there are problems of feed supply. Efforts to raise improved breeds of livestock in these areas, therefore, may be futile.

***b.* Alternative courses of action.**—1. *The Marshall and Caroline Islands.*—If meat or eggs from local sources are desired following occupation, the choice, at the beginning, may be confined to animals already being raised, mainly chickens, ducks, and pigs. Problems connected with the introduction of other breeds make it doubtful that introduction on a large scale should be attempted until adaptability has been demonstrated clearly.

It may be expected, however, that the normal population of local types of livestock will have been reduced considerably, and any plans for reliance on these products are probably unwise until the actual supply has been determined. In the event that local animals are utilized, the establishment of slaughter houses, or of some other arrangement to provide for inspection, would be advisable.

The fact that dairies have already been established in the four districts of Ponape, Truk, Yap, and Palau suggests that milk production of some kind is possible. According to the Japanese reports, however, the total quantities produced were so small that reliance could hardly be placed on this source for general use. Some might possibly be provided to help meet the needs of hospital cases. If there is interest in developing this possibility, the methods used in former dairies should be investigated. Details to be looked for would be the breeds and types of animals used, the precautions used against diseases and parasites, and method of feeding.

The improvement of swine might be brought about by crossbreeding. Reports that plagues sometimes take off as high as 75 percent of the poultry stock make it questionable whether the introduction of improved western breeds of this class of livestock could be done successfully. Improvement of local stock could be brought about by culling and selection; and crossbreeding might be done successfully, using cockerels of hardy breeds such as the Leghorn. For dairy and beef cattle, the greatest hope for improvement seems to lie in some use of Indian breeds.

2. *The Marianas Islands.*—In the Marianas, an immediate problem with respect to livestock may arise if most of the Japanese inhabitants are removed from their farms. That would leave without care a large part of the livestock still alive. Under such conditions there is danger that the usefulness of many head might be lost, and the number of animals available for later use might be greatly reduced. Possible courses of action are: (1) the stranded animals might be placed under care of native farmers; (2) the better animals might be selected to serve as the basis for livestock production under supervision; or (3) whatever is left might be rounded up and fed in centers, to provide a source of meat for troops, or for Japanese internees.

For feed, in case large numbers had to be provided for, temporary rations might be made up from materials locally available. Cattle might be pastured on uncultivated hillsides. Sugarcane makes a nourishing and palatable forage and, if it is dry, some molasses poured over it greatly increases palatability. The addition of corn, together with protein supplements such as fish meal, coconut meal or cottonseed meal, up to 10 per cent of the total grain mixture, would provide a fairly well-balanced ration. When cattle are pastured on fresh sugarcane for the first time, however, they should start gradually, feeding only one or two hours at a time, in order to prevent bloating.

For swine, kitchen refuse kept free of glass and other foreign matter would constitute a valuable item. Corn, with fish meal or coconut meal up to 10 per cent of the grain content, would improve the ration. Manioc roots should not be used without being cooked to drive off the prussic acid; but cooked, with molasses added, they make a good feed. For poultry, corn, millet, barley, or rice might be used, preferably with the addition of some protein supplement such as fish meal. But fowl could also live on fresh coconuts, the common poultry feed on Guam.

Prospects for the development of improved forms of livestock on these islands appear to be better than on the other island groups. This is indicated by the drier climate. It is also indicated by the comparatively large numbers of livestock normally raised on these islands, including Guam. And the reports that flocks of good breeds of poultry have survived on Guam also present hopeful evidence. This experience with poultry on Guam would be particularly valuable if there is interest in poultry raising. Breeds, housing, feeding, and control of parasites and diseases would be worthy of particular study.

3. *Technical assistance.*—It may perhaps be doubted whether, in the period immediately following occupation, there will be much interest in local animal products as a regular source of supply. In

Unless some Japanese labor can be utilized for these purposes after occupation, therefore, serious difficulties may be encountered in carrying out any large-scale activities. In accordance with international understandings, the labor of interned Japanese civilians can be used, providing that it is on a voluntary basis and that compensation is paid. It may also be, since many of the laborers will probably be found to be Koreans or Loochoo Islanders, who are less fanatically Japanese than the Japanese from the homeland, that their services can be utilized without endangering security.

Implements.—The kind and quantity of equipment necessary will depend on the extent of the activities, as well as on the kind of labor employed. Most natives will prefer the type of implement they are accustomed to using. The four general types of implements used in these islands are a kind of spade, a *machete*, an axe, and a kind of wooden rake. The use of power machinery will be possible on islands like Saipan and Tinian. It may also be usable on Rota. On Guam, it will be less useful, although one skilled in its use may be able to clear land of rocks in order to open for cultivation large fields. Implements that would be useful in such operations include tractors, mouldboard plows, disc plows, disc harrows, planters, drills, and cultivators.

3. ANIMAL PRODUCTION

***a.* The situation.**—In considering supplies from fresh animal products that might be obtained in the area, supplies of fish would normally be thought of. This subject is discussed in OPNAV 50E-20, Restricted, Civil Affairs Guide, *The Fishing Industry of the Japanese Mandated Islands.*

1. *Local animal production—Marshall Islands.*—Pigs, chickens, and ducks have been kept on many islands of this archipelago, mainly for sale to foreigners. The Japanese are reported to have introduced boars in an attempt to improve the stock of native pigs, which are black in color, of medium size, and have a small skull. The poultry raised are of native types apparently adapted to local conditions, but they do not lay many eggs. Cattle do not thrive, the native grasses apparently not providing sufficient nourishment.

Caroline Islands.—Pigs and poultry, before the war, became of increasing importance as a source of supply for the Japanese population. Most households kept chickens and ducks, and many had special henhouses. The number of pigs was large, and there were smaller numbers of cattle and goats.

The greatest menace to poultry is the rat, which eats the eggs. Plagues, which take off as high as 75 percent of the stock, are also said to have appeared.

Mention has been made of dairies also. In 1937, one dairy was reported in each of the districts of Truk, Ponape, Yap, and Palau. In each of these districts, also, there was a supervised slaughterhouse.

TABLE 9.—*Animal products reported produced in the Carolines, 1937*

	Truk district	Ponape district	Yap district	Palau district
Poultry meat.....pounds..	2,252	6,731	9,206	12,781
Hen's eggs.....	173,380	378,876	257,710	247,968
Duck's eggs.....	17,080	11,325	660	5,080
Meat (except poultry).....pounds..	39,379	94,624	10,601	126,338
Milk.....gallons..	1,769	1,627	.....	3,929

Marianas Islands.—Stock raising in the mandated Marianas Islands has been mainly in the hands of the Japanese. In 1937 it was reported that there were about 61,000 chickens, 7,000 pigs, and 8,000 ducks. There also were nearly 5,000 cattle, used mainly for labor. The supply of eggs and of pork apparently was sufficient to meet the needs of the Japanese residents. In an attempt to improve the stock, boars and bulls were introduced.

TABLE 10.—Animal products reported produced in the Mandated Marianas, 1937

Poultry meat.....pounds..	64,432
Hen's eggs.....	1,890,529
Duck's eggs.....	131,013
Meat (except poultry).....pounds..	513,572
Milk.....gallons..	12,672

On Guam, reports indicate that every farm has a few chickens, a pig, and a cow or water buffalo. Attempts have been made to improve swine by the introduction of improved boars, but improved types have not yet come into general use. Farms on which large flocks of purebred chickens have been successfully raised, however, have been reported.

2. *General considerations.*—General problems connected with the raising of improved types of livestock in tropical latitudes resemble those which already have been stated with regard to the production of vegetables. The degree of adaptation to factors in a tropical environment possessed by animals, including adaptation to temperature and to local strains of diseases and parasites, appears to be a matter of inheritance like size or capacity to produce milk. The Holstein cow, for example, does well in

FIGURE 23.—Ponape Island. Fields (probably rice) surrounded by dense jungle vegetation, east of Mailap on west coast (1944).

FIGURE 22.—Palau Islands, Koror Island. Cultivated fields (probably irrigated rice) (1944).

FIGURE 21.—Yap Island. Cultivated patches along northern part of west coast (1944).

applied to the soil to maintain it in a favorable condition. For immediate use, commercial fertilizers alone probably would have to be relied upon. In Guam experiments, best results were usually obtained when nitrogen, phosphorus, and potash all three were applied. Quantities used in the experiments consisted of 240 pounds of Chilean nitrate (16 percent N), 495 pounds of acid phosphate (15 percent P_2O_5), and 240 pounds of potassium sulphate (42 percent K_2O) per acre. This was "broadcast" and worked well into the soil before the planting was done.

For calcareous soils, like those on Saipan and Tinian, ammonium sulphate would be somewhat better than Chilean nitrate in most cases. But the best chemical to use would be ammonium phosphate, which combines 11 percent of nitrogen and 48 percent phosphoric acid (produced by Consolidated Smelting and Mining Corporation, Trail, British Columbia, Canada). To get approximately the same quantities of the essential nutrients as provided in the above materials, a good mixture would be the following: Ammonium phosphate—155 pounds; ammonium sulphate—130 pounds; potassium sulphate—240 pounds.

"Broadcasting" is sometimes considered to be the least efficient way of applying fertilizers. If mechanical planters are used, the fertilizers should be applied at the time of planting, in the machine. If planting is done by hand, fertilizer may be scattered in the row and hoed into the soil before dropping the seed.

A deficiency of available iron, in some soils of Guam, is shown by plants in a marked loss of green color, particularly in leaves of the upper part of the plant, the veins commonly remaining green. The natives sometimes put tin cans in their fields, a strange practice which in this case is probably useful. Ordinarily, the deficiency may be overcome by spraying the ground with a solution of iron sulphate.

Insect and disease control.—Numerous insect and disease pests are found on these islands. They include: Corn—ear worm, corn borer; stored grain—weevils; root crops—grubs; string beans—leaf miner, pod borer; radishes—aphids; cucurbits—powdery mildew, plant bug (*Leptoglossus Australis*), melon fly; leafy vegetables—diphana; beets—leaf roller.

On Guam, vegetables are raised by the natives for the most part without the use of chemicals in disease and pest control. A good deal of natural control is obtained by rotating crops, by burning infested crop refuse, by planting resistant varieties, and by planting when diseases are least prevalent. A fair degree of success may often be obtained, therefore, without resort to chemical methods of control.

However, insecticides and fungicides will be helpful, and sometimes may save a crop. If cabbage and beans are dusted with rotenone worms can be controlled. By spraying beets with lead arsenate leaf rollers can be controlled. The leaf miner that attacks beans is controlled by spraying at intervals of 8 to 10 days with nicotine sulphate. Dusting with sulphur reduces the infection of powdery mildew. Aphids are controlled by spraying with nicotine sulphate. These and other materials are applied with dusting and spraying apparatus which is made in a large variety of sizes suitable to different circumstances. Concrete advice, applicable to a specific plan, can be given by an entomologist as to the type and quantity of insecticides and fungicides that ought to be provided, and the kind of equipment most suitable for the job.

Seed storage.—Under humid tropical conditions seed deteriorates rapidly. For this reason imported seed should not be brought in until the ground is ready for planting. Fine seeds like beet, carrot, and radish may lose a great deal of germinating power within 2 or 3 weeks. Most seeds of any kind will deteriorate if held longer than 3 months. For that reason it is important to exercise special care to preserve any seed which, for one reason or another, is held for planting. One such situation would arise if local seed were selected for planting the following season. Such seed should be thoroughly dried, sunned, and then placed in a container. Bottles, glass jars, tin boxes or drums might be used. Whatever it is, the container must be fully airtight and dry. Bottles should be stoppered, with a layer of oil, thin grease, or vaseline on the stopper. Drums should be sealed or closed in some other way so as to be airtight. To absorb moisture that might be inside, bags of powdered lime should be placed among the seeds.

Labor.—In all the island groups, immediately upon occupation, a shortage of labor for agricultural purposes may reasonably be anticipated. Field reports indicate that, in the Marshall Islands, able-bodied males were taken away by the retreating Japanese. Also, immediate demands upon available manpower may be expected for construction of military installations and similar purposes. As the demand for labor for other purposes gradually decreases, it is to be expected that more native labor will become available for agriculture, assuming that proper incentives can be provided. However, in the east and west Carolines and in the mandated Marianas, labor engaged in commercial vegetable production seems to have been largely Japanese.

be used to grow pineapples for consumption on other islands of the mandated area. The soil apparently is suitable, and there should be available at least some labor skilled in the production of this crop. It would be practicable, however, only if space were available to ship the fruit to desired points under refrigeration. The pineapple variety also would be important. Those best for canning are usually not good for shipping, because highly perishable. Such a project could be undertaken, therefore, only if suitable varieties are adapted there.

3. *The Marianas Islands.*—Assuming that a significant portion of the former sugarcane acreage on Saipan, Tinian, and Rota can be used for other purposes, the land available for vegetable and fruit production on these islands should be large even if a considerable amount is used for military installations. In some respects, also, the climate is unusually suitable. From these points of view, therefore, conditions are exceptionally favorable in comparison with conditions elsewhere in the mandated area.

The prospect for success in vegetable and fruit production on these islands is particularly promising, also, because a good deal of information will be available from Japanese experiments and experience, and from American enterprises on Guam. Furthermore, a great deal of the information from Guam is available in advance of occupation. Of course, what has been learned concerning Guam will not necessarily apply in all cases to Rota, Tinian, and Saipan, but conditions are sufficiently alike that a great deal should be applicable. In the following statements there are summarized pertinent points in the information concerning Guam.

Varieties and planting seasons.—*General.*—In Guam, although some vegetables may be grown any month of the year, most of the planting is done in two general seasons: one, before the rainy reason, the latter part of May and through June; and, two, after the rainy season, from September through December or January. The latter is the more favorable season, but conditions become less favorable as the dry season approaches. For this reason the supply of vegetables gradually falls off, vegetables being particularly scarce during the months of April and May. In the lowlands of Guam, yields continue good at least through April.

Corn.—Several American varieties of sweet corn have been tried on Guam, but they usually succumb to attacks of local insect pests. The local variety of field corn, however, is reported to produce very good roasting ears, and this grows well on Guam. For summer production, corn may be planted as early in June as the rains come and at intervals through that month. For late fall and early winter use, plantings are made at intervals through September. Success is not to be expected when planting is done later than September.

Cucurbits.—(Cucumbers, pumpkins, squash, muskmelons, and watermelons.) Because of the prevalence of powdery mildew, these crops will succeed much better when planted after the heavy rains have stopped. Planting may begin the latter part of October and continue at intervals through November and December. Some mildew may still be found at this time, but attacks are usually not serious; and excellent crops of all these types of vegetables often can be obtained.

The following varieties have been grown successfully:

Cucumber	Fordhook Famous.
Squash	Mammoth White Bush Scallop.
Pumpkins	Most of the ordinary varieties.
Watermelon	Tom Watson.
Muskmelon	Burrell's Gem.

(NOTE.—Newly developed varieties of muskmelons resistant to the powdery mildew, should be tried here; Powdery Mildew resistant No. 45, and No. D–2.)

Cabbage.—Difficulty is usually experienced in getting cabbage to head. According to past experience, many varieties will not head at all and the best varieties are not likely to produce heads on more than 60 percent of the plants. The varieties that have been used most successfully are All Season and Surehead. Seed is planted in seedbeds about December 1, and plants are set into the field from 6 to 8 weeks later, when moisture is sufficient. Usually only one planting is possible.

Chinese cabbage.—Chinese cabbage grows well in Guam. The Wong Bok variety is recommended. Plantings of this may be made at almost any time in the year when there is sufficient moisture.

Onions.—It is not easy to raise onions to maturity, but very good green onions have been produced by planting onion sets. Apparently most of the standard varieties will do. These may be planted either in June or through September, October, and November.*

Fertilizers.—Experiments on Guam have shown that yields of vegetables are often greatly increased through the use of fertilizers, particularly during unfavorable seasons. For long-time use, green manure and other types of organic fertilizers should be

*For more discussion of vegetables, see Appendix II.

Where no good soil is found, if interest in gardens is sufficient, consideration might be given the raising of vegetables on poor soil through a frequent application of easily soluble fertilizers. One application could be hoed into the row or hill before planting, and subsequent applications might be scattered along the row and hoed into the soil at intervals of 2 or 3 weeks. A mixture consisting of 100 pounds of ammonium sulphate, 150 pounds of superphosphate (20 percent P_2O_5) and 100 pounds of potassium sulphate ought to be effective.

For limited use, the Germans are reported to have introduced a small amount of fertile soil from other islands; and one Japanese gardener is said to have brought from Kusaie enough soil to establish an acre of good vegetable land on Jabor Island. This procedure might be considered as a possibility. A study of previous results would help to determine its practicability.

For production on a larger scale, if vegetables are urgently needed, and assuming that labor is available, it might be possible to level an area of sufficient size and make frequent applications of quantities of the fertilizer mixture mentioned above. For the use of their troops on the Marshall Islands, the Japanese attempted large-scale garden production on Kusaie, 425 miles from Jabor. This method may have sufficient merit to warrant consideration; and the results of their efforts might well be investigated.

Where good soil is as scarce as on these islands, hydroponics ("soil-less farming") naturally suggests itself for consideration. Technical advances during recent years have placed this method of production on a more substantial foundation than formerly; but a successful experience under a wide variety of conditions is still lacking. Except on an experimental basis, therefore, it is of doubtful advisability.

Following any of these plans, one would still have the problem of deciding what to do with regard to varieties, methods of preparing seedbeds, and methods of planting. For the Marshall Islands very little can be said about such matters in advance of a study on the spot. The best guide on all these points is to observe what has been done and to learn from those who have done it.

2. *The Caroline Islands.*—For small-scale production of vegetables or fruits on any of the coral islands of this group, the same approaches as discussed with regard to the Marshall Islands should be considered. If large-scale production is contemplated, the natural centers for such production would be the islands of Ponape and Kusaie in the east Carolines, and islands of the Palau group in the west Carolines.

Results of certain experiments with vegetable and fruit production in these areas is given in a report of the Industrial Experimental Station on Palau, for 1932, a translation of which appears in Appendix I. Japanese varieties of many vegetables with names not used in the United States are recommended, including sweetpotatoes, eggplants, cucumbers, white muskmelons, turnips, radishes, green onions, and peas. Of varieties common in the United States, the following are listed as the best: Watermelon—Improved Florida; Chinese cabbage—Shangtung cabbage (Cheefoo); Squash—Hubbard. A further list of vegetables is discussed in some detail under the next heading, where experience on Guam is presented.

Although it is by no means certain, a guess might be made that most of these vegetables could be used with some degree of success in the Caroline Islands, except in the case of cucurbits, including cucumbers, squash, pumpkins, muskmelons, and watermelons. Since the varieties indicated in the Guam list ordinarily cannot be grown successfully during the rainy season, it is questionable whether they would do well in the Carolines, where there is no dry season. Other varieties mentioned might be considered for trial.

The logical procedure would be to study methods of production under the Japanese. From observation, as well as from a study of recent experiment station reports and inquiry of natives or Japanese who had raised vegetables, one could learn what was actually successful there. Matters for inquiry are: variety used, time of planting, method of preparing ground for planting, method of planting, and means used to control insect and disease pests. In any event, a great many details an outsider could hardly anticipate are involved in the production of vegetables but they would be fully understood by those who have done the work. Therefore, it would be wise to employ trusted local persons as foremen or chief gardeners, and to leave responsibility for details with them.

Experiments on Palau show that fertilizer is badly needed. In addition to increasing yields, fertilizers produce healthier plants which seem better able to resist pests. From information available, it appears that on volcanic soils applications of the following amounts per acre would be effective: Chilean nitrate, 250 pounds; superphosphate (20 percent P_2O_5) 300 pounds; and potassium sulphate, 250 pounds.

With regard to fruit, the large acreage of pineapples reported on Palau suggests that this island might

only sparsely cultivated, the cultivated fields existing mostly as isolated patches of small size. However, Guam also has lowlands, areas which are water-logged and suitable for rice production during the rainy season, but which dry out sufficiently by December or January to permit planting of vegetables under semi-irrigated conditions. By means of clearing and development of irrigation facilities, an additional 2,000 acres of lowland might be brought under cultivation. According to calculations, between 6 and 8 small dams would be required, involving a total expenditure estimated to be at 10 to 12 thousand dollars, if simple structures like those now in use are constructed. Expansion of upland cultivation would be difficult, unless the use of power machinery makes it possible to clear fields of stones.

2. *Adapted crop types.—Marshall Islands.*—Judging by past production of vegetables in the Marshall Islands, it appears that tomatoes, corn, beans, eggplant, pumpkins, squash, cucumbers, radishes, and lettuce can be grown if varieties suitable to tropical conditions are selected. Of the fruits, bananas have been grown, although they are said to be of poor quality. Other fruits grown are papayas and pineapples.

Caroline Islands.—According to one source, the list of vegetables of which varieties adapted to Ponape have been introduced include cucumbers, eggplant, tomatoes, radishes, okra, lettuce, napa, carrots, onions, squash, pumpkins, melons, watermelons, cabbages, kohlrabi, peas, beans, spinach, potatoes, and sugar potatoes. This, however, may be too optimistic an estimate of the possibilities. Of the vegetable crops grown commercially in that district in 1937, sweetpotatoes, yams, watermelons, cantaloupes, pumpkins, cucumbers, eggplant, Asiatic radishes (*daikon*) and Asiatic turnips (*busei*) were mentioned. In the Palau district, vegetables grown commercially included eggplant, pumpkins, cucumbers, Asiatic radishes, watermelons, and muskmelons. Fruits grown in the Ponape district included bananas, papayas, pineapples, and mandarin oranges; and all of these, with mangoes, were grown in the Palau district.

Marianas Islands.—Vegetables reported in commercial production in the mandated Marianas Islands in 1937 include sweetpotatoes, yams, beans, taro, watermelons, pumpkins, cucumbers, casaba melons, muskmelons, eggplant, Asiatic radishes, Asiatic turnips, carrots, burdock, and onions. On Guam, in addition, success has been had with string beans, lima beans, beets, cabbage, cassava, collards, okra, peppers, squash, and swiss chard. Good roasting ears are obtained from the local variety of corn. Of the fruits, bananas and papayas occupy the greatest acreage in the mandated Marianas, but mangoes, pineapples, and tangerines are also grown. On Guam, avocadoes and limes also do well.

3. *General considerations.*—It has already been mentioned that difficulties may be experienced in growing vegetables under the conditions which exist in the mandated islands. For one thing, there are some types of crops like the Irish potato, which will seldom succeed at all under these conditions. Varieties, also, may differ greatly in their adaptation to such things as length of day, temperature, and soil. It often happens that one variety of a crop will produce a satisfactory harvest in a certain locality while another variety grown there will fail. Furthermore, a division of the year into four seasons virtually does not exist in the tropics, and the time for planting things, therefore, will often be different from those in a temperate climate. The alternation between wet and dry seasons may also make a difference. Muskmelons will usually succumb to mildew in Guam if planted at the beginning of the rainy season, but excellent melons are often obtained by planting in November, when the heavy rains are past.

These examples will serve to emphasize why caution needs to be exercised when planning projects. They will also explain why the best answer to many questions of procedure will often be found not in preliminary studies but on the spot. These answers will sometimes be provided in information gathered by scientific experimentation in local agricultural experiment stations. They may also be provided by the natives.

One additional point should be mentioned. Since so much of the success of agricultural ventures in these islands will depend on an accurate observation of what is found in the area and on sound judgments, an unusual necessity for assistance from qualified technical personnel is indicated. To one trained in this field, a great deal which to others might go unnoticed would be clearly evident. It seems important, accordingly, that such personnel should be at hand as soon as possible after occupation, to study and to preserve the results of local experimentation and experience, to assist in planning courses of action in agricultural matters, and to make detailed estimates of what will be required for putting plans into effect.

What follows below, therefore, cannot be considered as a complete guide to action. It represents, simply, the best judgment it seems possible to make without information that studies on the spot can provide.

***b.* Alternative courses of action**—1. *Marshall Islands.*—For small gardens possibilities may exist where patches of relatively fertile soil can be found.

are removed. It might be mentioned also that roots do not necessarily have to be harvested at a specific stage of growth, but they may be allowed to remain in the ground for some time after maturity and used gradually. They spoil quickly in the open air.

***d.* Alternative uses for land in manioc.**—The use of this land for the production of vegetables and fruits is discussed in section IV, Production of Fresh Foodstuffs for Occupying Forces. If after the need for vegetable land has been taken care of, more land is available on Ponape and Palau, rice should be considered, as a source of supply for native consumption. Too little is known about rice production on these islands to state whether or not rice can be grown readily, or whether the natives will undertake its production. Rice was grown both on Ponape and on some islands of the Palau group. If more rice is to be grown, the methods already in use should be followed. Also, seed should be taken from native varieties. Until other information is gained from additional trials or experimentation, nothing better can be recommended.

Should no special use be found for this land, it might be turned over to refugees from other regions or to the local natives. Without attention it will quickly become a jungle.

IV. PRODUCTION OF FRESH FOODSTUFFS FOR OCCUPYING FORCES

1. THE PROBLEM

The production of fresh vegetables, fruits, or animal products for occupying forces may conceivably be desired for a variety of reasons. Undoubtedly a great deal can be accomplished along these lines by following suitable procedures, but undertakings of this kind are not to be thought of merely as going ahead in ways which one would follow in the United States. Tropical conditions make nearly all such undertakings more difficult, and procedures are different. Success can often be secured, however, by following practices which have been found successful in the locality. (Acknowledgment is made of the use, in this section, of material relating to the Marshall Islands reported by Knowles A. Ryerson, Special Representative of the Foreign Economic Administration, South Pacific Project, following a trip of inspection on Majuro.)

2. VEGETABLES AND FRUITS

***a.* The situation**—1. *Soil resources — Marshall Islands.*—Soil on the Marshall Islands usable for fruits and vegetables is limited in area and, for the most part, poorly suited to such purposes. On some islands there is practically no good soil. On others, where good soil exists, it is usually spotty and the land is uneven. Were the land to be leveled with an implement like the bulldozer, the average fertility would be lowered, and larger quantities of fertilizer would be required.

East Caroline Islands.—Soil conditions on coral elements of the Carolines are no more favorable than in the Marshalls. Soil on the volcanic islands of Truk, although said to be inferior to that on other volcanic islands, appears to be more abundant and generally of better quality than on the coral islands.

On Kusaie, however, appreciable areas of good agricultural soil exist along the coastal fringe as well as in an interior transverse valley. On Ponape, in addition to land in commercial vegetable production, the large acreage in manioc might be available for vegetables and fruits. These islands also have some elevated sites on Ponape. However, the thinness of the soil-covering on slopes and the dense jungle-type vegetation in the interior make it questionable whether any temperature advantage, because of elevation, can be utilized.

West Caroline Islands.—In the west Carolines, soil areas of larger size appear to exist mainly on islands of the Yap and Palau groups. In the Yap group fertile soil is reported on the islands of Rull and Tomil, and small areas are undoubtedly available on other islands. As reported in 1937, however, practically all the cultivated land of Yap was devoted to the production of the basic foodstuffs used by the native population.

In the Palau group, the island most important for agricultural purposes is Babelthuap, but Arakabesan, Malakal, and Koror are also volcanic. In 1937, in this district, there were about 235 acres devoted to production of miscellaneous types of vegetables. In addition, for possible use in vegetable and fruit production, there were over 900 acres in manioc and about 1,000 acres in pineapples.

Marianas Islands.—On most of the islands of the east and west Carolines, cultivated agriculture is usually confined to patches of land, often quite small in size and frequently surrounded by jungle growth. In the Marianas Islands areas under cultivation are large. This is particularly true of Tinian, nearly three-quarters of which was reported to be cultivated. A smaller proportion of Saipan is cultivated, but large cultivated areas are spread out over its northern and southern ends.

On Rota, cultivated fields are scattered; and this is even more true on Guam. The uplands of Guam are

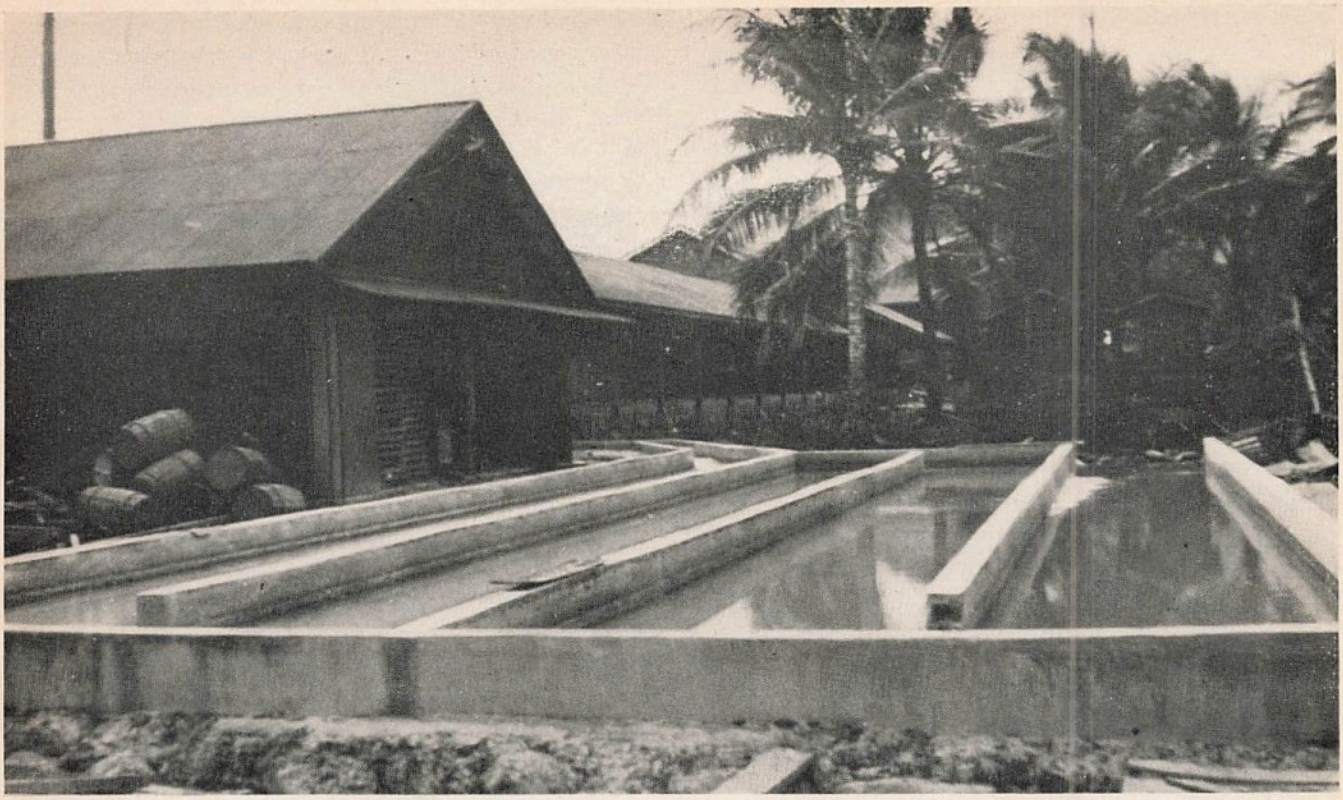


FIGURE 19.—Ponape Island. Tapioca starch works, Metalanim, Chapalak River (no date).

FIGURE 20.—Ponape Island. Colonist farm, Palikir agricultural settlement (no date).

TABLE 8.—*Manioc and starch production, 1937*

Island	Area planted	Production of manioc roots	Tapioca manufactured	Yield per acre of manioc roots
	Acres	*Short tons*	*Short tons*	*Short tons*
Ponape	1,284	11,177	2,180	8.8
Palau	902	5,173	Not reported	5.7
Saipan	3,620	12,576	2,228	3.5

***c.* Current demand for tapioca starch.**—There exists among the United Nations an acute shortage of root starches, which are important in the manufacture of certain adhesives and textile-sizing material. Because of the development of substitute products, and of new sources of root starches in Latin America, it is expected that, shipping permitting, the present critical situation will have passed by the end of 1944. The readiness with which tapioca starch can be absorbed in the United States after that time will depend upon the price at which it can be offered on the market. When ample stocks of this product are available, it must be sold in competition with other products of similar properties and uses.

***d.* Land in manioc.**—The question of other agricultural uses for land in manioc would not be of much importance in Saipan, since sufficient acreage for all purposes is available there in former sugarcane land. The situation may be different on Palau, and especially on Ponape, where the amount of land available for agricultural purposes is distinctly limited. Furthermore, land devoted to manioc is usually of good quality, well drained and of good texture. The excellent yields reported on Ponape indicate a particularly fertile soil. Also, the quantities are appreciable. In 1937, 1,285 acres were reported in this crop; and it has been reported that in 1936 the large valley of Metalanim was being thoroughly cleared for the planting of more manioc. Much or all of this land should be suited to the production of any of the crops adapted to the climatic conditions of this area.

3. ALTERNATIVE COURSES OF ACTION

***a.* Utilization of available supplies of starch.**—If supplies of tapioca starch are found at the time of occupation, consideration might be given to the use of limited quantities as a foodstuff for Japanese internees. In Brazil tapioca flour is used together with wheat flour for making bread, up to 20 per cent of the total quantity used. It can also be used as a base in puddings, and it can readily be used in the making of such products as crackers and pancakes. As a food, it is entirely starch, and of value only for its calories.

If the quantities found are large, they would be very useful in helping to relieve the current shortage of this product among the United Nations, assuming they could be shipped to reach the United States before the end of 1944. Subsequent to that time, while the market probably would readily absorb all that could be shipped, the present urgent need in the United States for root starches should be largely past.

***b.* Disposal of the starch industry.**—Decision with regard to disposition of this industry would depend on the situation found at the time of occupation, mainly with respect to the following four factors: (1) condition of the starch-manufacturing equipment; (2) other demands for the use of land formerly in manioc; (3) possible local reasons favorable to continuation of starch production; and (4) the supply of labor and managerial and technical personnel. If, upon occupation, other and urgent uses are found for the manioc land, it had better be converted.

Should the land not be needed for other purposes, the decision should be based mainly upon whether or not important local reasons are seen for rehabilitating the industry. If there are large quantities of manioc root in the ground, not usable in other ways, it might be profitable to turn them into starch. If there are surplus quantities of labor, they could be employed in this way; and the export of manioc starch would provide a source of income to purchase imports. Rehabilitation should not be difficult. Precipitation tanks are made mostly of cement, and the machinery involved is not complicated. Furthermore, the price of manioc starch may be expected to continue good through 1944 and 1945.

But in normal times competition from other sources makes it appear doubtful that the industry on these islands could continue without a subsidy.

***c.* Disposal of manioc.**—If normal plantings of manioc were continued in 1944, and unless it is decided to use this crop in the manufacture of starch, rather large quantities of manioc root may be found unharvested. Except for use in the manufacture of starch, the only common use of this root is in direct consumption. If the natives are not accustomed to eating it, this root may not be eaten now with relish, but it might properly be considered for use in relief, or as a starchy vegetable for Japanese internees. Some who have eaten it consider it a reasonably good substitute for the potato.

If such a use is attempted, however, it ought to be pointed out that, in its raw state, this tuber contains poisonous substances. Exercise of proper precautions in its preparation should be emphasized. If it is peeled and then boiled, the poisonous elements

FIGURE 18.—Marianas Islands, Rota Island. Typical scattered sugarcane cultivation (1944).

readily be obtained in Guam, where information on methods of planting and handling also could be obtained.

5. *Sweetpotatoes.*—Sweetpotatoes derive special mention as a crop which, with corn, might be used to some extent as a substitute for rice in the diet of both the natives and the Japanese internees. Although rice would probably be preferred, sweetpotatoes form an important item in the diet of rice-eating peoples in a number of Asiatic areas, and a considerable expansion of the acreage here would be advisable for that purpose. This crop is usually propagated by planting shoots which spring up from tubers or parts of tubers buried in soil or sand. No doubt the preparation of the land and the cultivation of the crop could be done with American plowing and cultivating equipment. But such things as date of planting, methods of securing plants, and details of setting them in the ground had better follow local practices.

III. TAPIOCA STARCH AND LAND IN MANIOC

1. THE PROBLEM

According to reports, small industries producing starch out of manioc root have been established on the islands of Ponape, Palau, and Saipan. Immediate importance attaches to this industry, especially on Ponape, because the manioc land could also be used for other agricultural purposes. The principal question appears to be whether the industries formerly established should be fostered, or whether they should be discontinued and the manioc land planted to other crops such as vegetables, fruits, or rice.

2. THE SITUATION

***a.* Manioc.**—Manioc is another name for the crop called cassava, a root crop from which tapioca starch is manufactured. The plant itself grows tall, with a spread of broad substantial leaves appearing at its top. In some places, as in Java, the Philippines, and Guam, the cooked tubers form a significant item in the native diet. In the mandated islands, although information is incomplete, the crop appears to be grown almost entirely for its use in the manufacture of starch.

***b.* Description of the industry.**—In the preparation of starch, the root of the plant is finely ground, after which the starch is extracted by soaking. The milky water is then run into outdoor precipitation troughs where the starch grains are allowed to precipitate. The starch-rich material is then gathered, heated to remove moisture, and finally bagged for export. The labor used in both the planting of manioc and the manufacture of starch appears to have been mainly Japanese.

FIGURE 17.—Marianas Islands, Rota Island. Rota village with sugar mill (1944).

tional point of view a mixed diet should be at least as good as rice alone. Corn can also be used as a feed for livestock. An expansion of the acreage in corn, therefore, is perhaps advisable.

If that course is decided upon, seed of local varieties should be used. Other varieties will succumb to pests. Seed is best obtained by selecting good ears from the field. But whether used for seed or for direct consumption, corn should be picked just as soon as it is mature. Otherwise a corn weevil will destroy it within 2 or 3 weeks It should be thoroughly dried, sunned, shelled, and put in airtight drums for storage. Native methods of storage should be examined, to make sure that no details of successful storage are overlooked.

On Guam there are two planting seasons for corn, in June and in September. Natives on Saipan, Tinian, and Rota should be consulted with regard to planting practices on these islands. Inquiry should also be made as to distance between rows, amount of seed used, methods of planting and cultivation. No doubt American corn planters could be used in fields where rocks are not too numerous. Cultivators used in the United States could be employed for cultivation. If planters are used, fertilizers could be applied at the time of planting. In the absence of more complete information, the quantities of fertilizers suggested for rice are suggested also for corn.

4. *Miscellaneous field crops.*—Of other field crops certain sorghums have done well on Guam, according to reports of the Guam Agricultural Experiment Station. This crop might be used as a feed for poultry or other livestock. The best producers have been Blackhull Kafir, Dwarf hagari, Sunrise kafir, Dawn kafir, Yellow milo, and feterita. The Guam station recommends that plantings be made after the rainy season is past, the best results having been obtained when plantings were made in January and February. It is recommended that rows be 36 to 42 inches apart, and plants be thinned to 8 to 12 inches apart in the row. Seeds are planted from 1 to 2 inches deep. American planters and cultivators could be used, as stated for corn; but the crop could also be planted and cared for by native methods. These would have to be determined by inquiry of natives who have grown the crop. From 3 to 6 pounds of seed per acre are required.

In addition, soybeans, peas, castor beans, coffee, and cotton have been raised in appreciable quantities. Yields of cotton are not large, compared with yields in areas where conditions are naturally suited to the production of cotton; and it is doubtful whether, apart from the Japanese economy, cotton has much of a place here. A pasture grass, papsalum, now growing readily in Guam, might be introduced to cover hillsides for pasture purposes. Stock for planting could

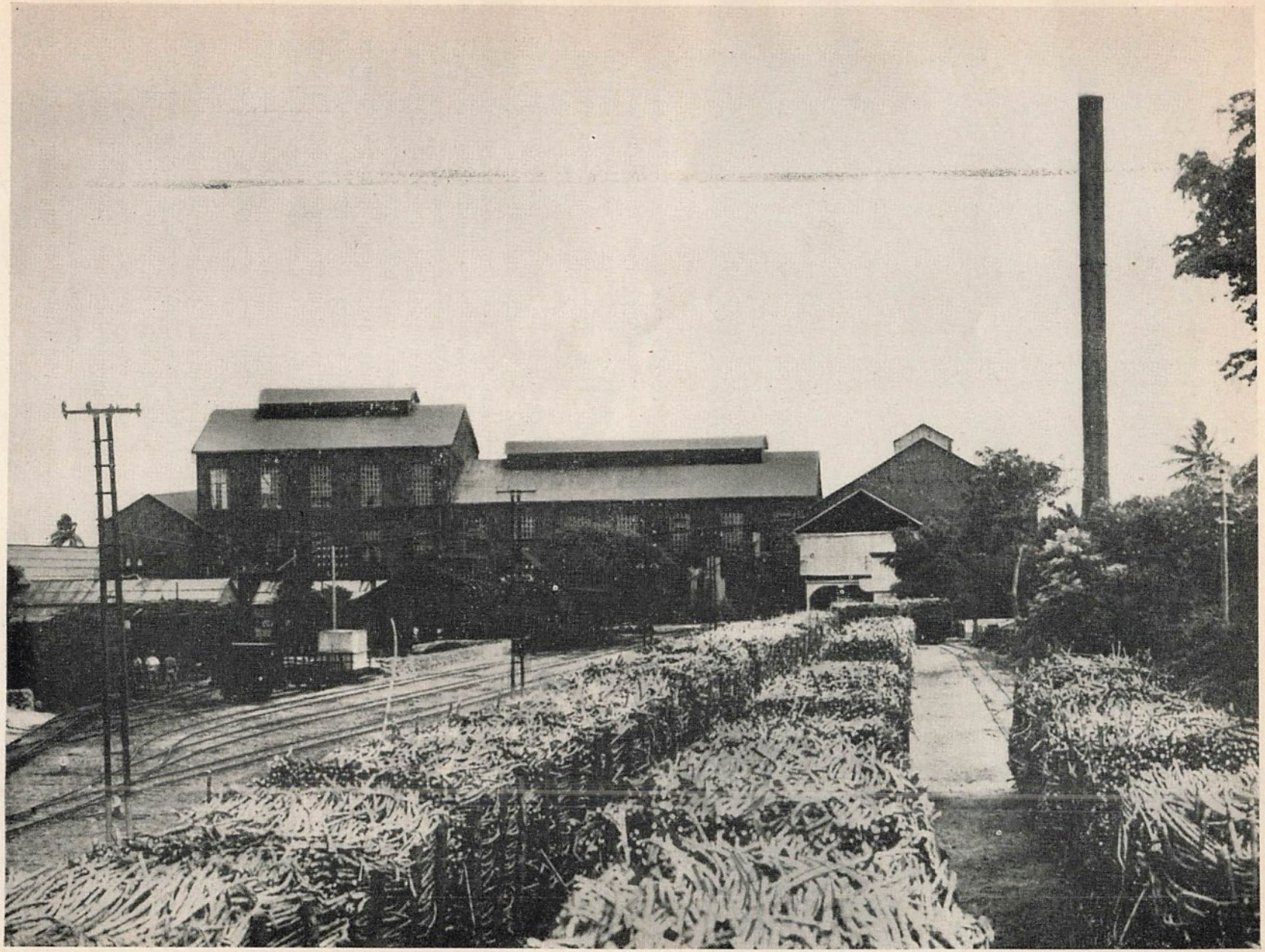


FIGURE 16.—Marianas Islands. Saipan Island. Sugar refinery, Charankanoa.

FIGURE 15.—Marianas Islands, Tinian Island. Tinian town, sugar mills and fields.

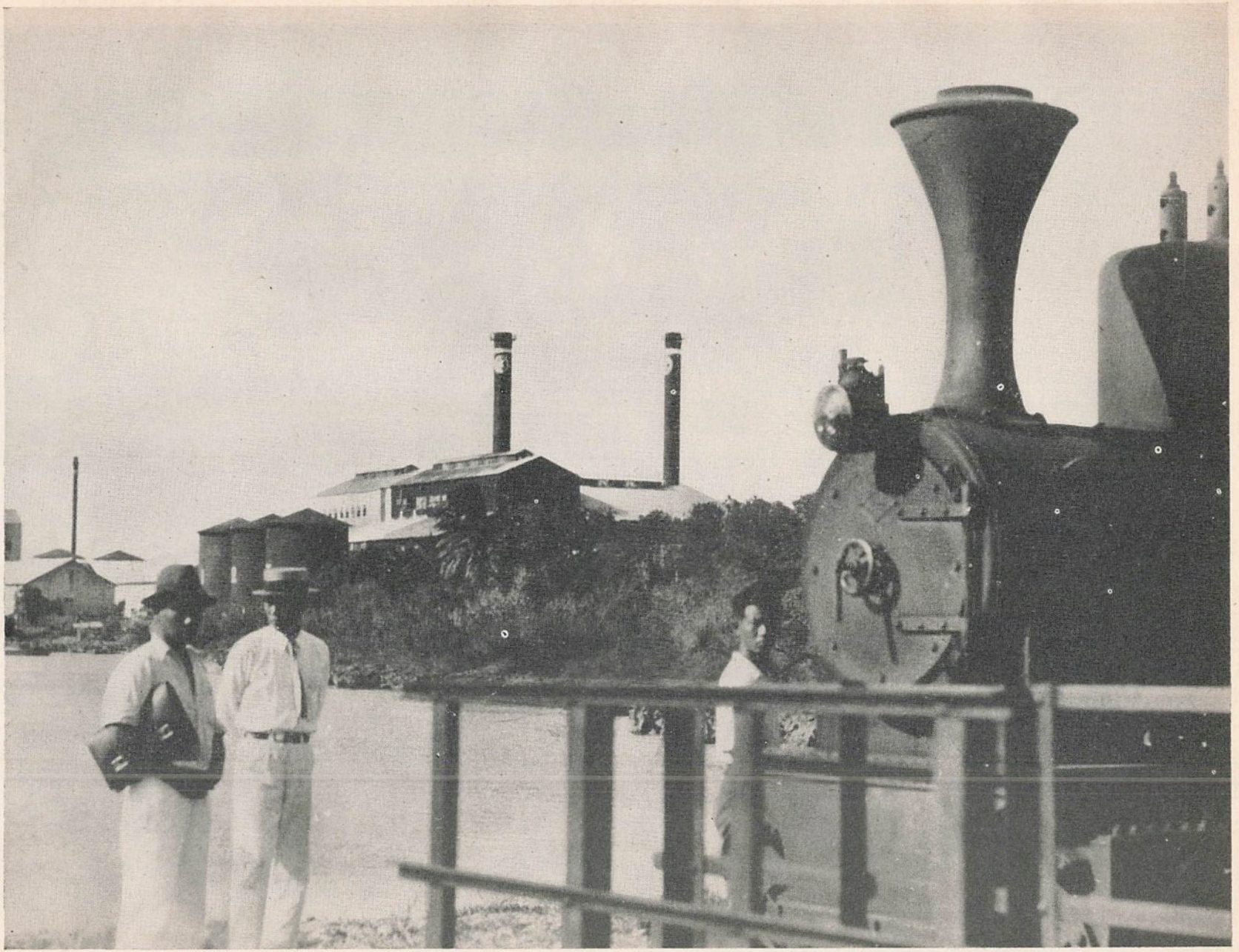


FIGURE 14.—Marianas Islands, Tinian. Sugar mill and small locomotive for hauling cane from fields to mill (prior to 1942).

alcohol distillation equipment can be salvaged, it may be found desirable to utilize this equipment for the production of alcohol, possibly for military use in the area.

3. With regard to the ultimate disposition of this industry, assuming that these islands remain under United States control, it is the opinion of sugar specialists of the Department of Agriculture, unless local conditions dictate otherwise, and unless a sugar industry on these islands can exist independently, that large-scale production of sugar should not be revived there. This course of action, however, would not preclude the possibility of maintaining a limited acreage for the production of unrefined types of sugar for the needs of local populations.

***b.* Uses of land released from sugarcane production.**—*1. Vegetable and fruit production.*—A great deal of the cultivable area of these islands would be suitable for the production of vegetables. Possibilities for using released land are discussed in Section IV, "Fresh Foodstuffs for Occupying Forces." For a discussion of the problem of labor refer also to that section.

2. *Rice.*—A need for rice in the mandated area, to supply native demand and possibly for the use of Japanese internees, indicates that a considerable proportion of land released from sugarcane use might be devoted to the production of rice. An examination of the situation, however, gives little hope that large quantities of paddy rice, grown under irrigation, can be produced. Small quantities of irrigated land appear to be available on Rota; elsewhere on these islands there is little or none, the small islands being devoid of streams or other sources of water. Furthermore, most of the soil is porous and not suited to holding water in paddies.

Rice production on these islands, therefore, appears to be limited to the possibilities that can be found in upland rice (dry-land rice), grown without irrigation; and only a small amount of information is available regarding the possibilities for that crop. Mention has been made of Japanese experiments with upland rice. In a report of the Industrial Experiment Station of Palau, it is stated that the best variety, in their experiments, was a Yap nonglutinous rice *hakumai hari* (white rice needle). But no acreage actually planted to upland rice is reported on any island.

If it is decided to plant rice, therefore, the only safe procedure which appears available, in the light of present information, is to make use of seed from varieties found growing there. This crop should be found in the field between July and the end of November. Upland rice looks about the same as paddy rice, a plant with leaves not unlike those of wheat or oats and with a head on which are clustered grains of rice enclosed in a husk, something like the grains of barley. Seed from such crops would probably be the best seed to use; and it might be found desirable to use the entire harvest for seed purposes. If occupation occurs after harvest, assuming that there has been a harvest, existing stocks might be requisitioned of farmers, although there would be some risk that other kinds of seed would be turned in. Careful comparison with seed that is known to be of the correct type would help to check on this matter. It is possible that grain from upland rice would not be as acceptable to the population as the imported types to which they are accustomed, but under an emergency situation such preferences presumably would not be given much consideration.

Methods of planting had best follow those already in use, which can be learned by asking native growers and by observing the crop in the field. Points to inquire into are time of seeding, depth of planting, distance between rows, rate of seeding, and method of seeding. Some cultivation would doubtless be necessary to keep the land free of weeds. American equipment such as tractors, plows, planters, and cultivators could be used on these fields. If it could be obtained, fertilizer applied at the rate per acre of 200 pounds of ammonium sulphate, 250 pounds of superphosphate, and 150 pounds of potassium sulphate should greatly increase yields.

For production in later years, it probably would be desirable to look beyond local seed sources. The results obtained in Japanese experiment stations should be examined, if available. Reasons for failure to develop wide use of this crop would be as valuable as information about success. In the United States Department of Agriculture a variety of dry-land rice, the Fortuna variety, has been developed from seed originally imported from Taiwan. Recently it has attained considerable importance as a commercial variety in Cuba and Colombia. Limited quantities of this seed might be imported, not for immediate introduction on a large scale, but for thorough and careful testing. Subsequently it might be placed in general use if the test results warrant it. Seed would be available in the Department of Agriculture. Also, varieties from the Philippines might be tried.

3. *Corn.*—Of the grain crops the greatest acreage was in corn, which also was a major crop on Guam. This can be used (as a food crop) to substitute for rice to some extent. People accustomed to eating rice do not readily accept corn in its place, but from a nutri-

1939, although slightly out of line with other official figures, give statistics on the production of sugarcane and sugar.

TABLE 7.—*Production and yield of sugar and sugarcane*

	Cane area in acres	Total sugar in tons	Yield percent cane	Sugar yield tons per acre	Cane yield tons per acre
1933–34	14,621	49,520	11.57	3.39	29.78
1934–35 [1]	19,760	74,933	12.58	3.79	30.19
1935–36 [2]	23,715	54,065	11.02	2.28	22.00
1936–37	28,337	63,434	10.90	2.24	20.54
1937–38	30,010	81,951	11.09	2.73	25.36
1938–39	28,556	77,332	11.85	2.71	22.86
1939–40 [3]	[3] 25,026	[3] 79,200	[3] 12.00	[3] 3.16	[3] 26.37

[1] 1934–35—Second mill in Tinian started operation.
[2] Rota mill started 1935–36, but discontinued 1939–40.
[3] 1939–40—Preharvest estimate.

Another source gives the following breakdown of acreages on Saipan, Tinian, and Rota in 1936 and 1938.

	1936 (acres)	*1938 (acres)*
Saipan	9,050	9,413
Tinian	14,234	14,800
Rota	4,807	6,187
Total	28,091	30,400

Of alcohol production, the following figures are reported for 1938:

	Gallons
Saipan	340,000
Tinian	430,000

***c.* Labor.**—While attempts were made early in the history of this industry to secure native laborers, these attempts were subsequently abandoned. In recent years, Japanese labor has been employed almost exclusively, with the following numbers reported in 1937:

In refining plants and transportation of raw materials	4,520
Plantation workers under direct control	6,500
Tenant farmers	9,700
Independent Japanese farmers	210
Independent native farmers	130
Total	21,060

***d.* Sugar situation among the United Nations.**—Currently, the supplies of sugar and of sugar products available to the United Nations fall short of meeting the total demand. The sugar situation will be improved when production is again under way in large producing areas, such as the Philippine Islands and Java. However, prospects for large additional supplies immediately upon occupation of these islands are not promising, considering the destruction reported. Probably very marked shortages may be expected for a year or two after the war ends, when the demand for relief purposes is also taken into account.

The long-term prospect for the United Nations, however, is not one of shortage. Previous to the war efforts were directed toward control or production so as to maintain a balance between supply and demand. From the standpoint of the United States, there appears to be little or no need for additional sources of supply as a long-term prospect.

***e.* War effects.**—Several rather obvious direct and indirect results of the war, which may affect plans for the future of this industry, are mentioned below. It may be assumed, first, that sugar-manufacturing machinery will incur damage, possibly complete destruction; and large items of equipment now are difficult to replace. Secondly, since the labor formerly employed was almost entirely Japanese, whatever remains of the original supply when fighting ends will consist mainly of enemy nationals. Thirdly, the services of qualified technical personnel, such as would be required to operate sugar mills, are not easy to secure at the present time. Furthermore, large portions of the growing crops, particularly of sugarcane, will be destroyed during military operations.

3. ALTERNATIVE COURSES OF ACTION

***a.* Disposal of the sugar industry.**—1. If mills are damaged to the extent that they require important replacement parts, difficulties to be expected in getting them back into operation, and doubt as to the value of a future sugar industry in these islands, suggest that no immediate steps be taken to revive the industry. This would leave available for other purposes some 30,000 acres of land suitable for the cultivation of vegetables, tropical and subtropical fruits, and certain grains.

2. If enough equipment can be salvaged to provide one or more operable units, assuming that labor together with managerial and technical personnel can be assembled, as much cane acreage as can be processed might be kept during the shortage of sugar and alcohol. If this is done, several alternative courses of action are open. If inward-bound tanker space is available, it might be found desirable to turn out only a high-test or invert molasses, obtained just short of crystallization. This product would be acceptable in the United States for use in the manufacture of alcohol, and its production would require a minimum of equipment and technical personnel. If tanker space or suitable facilities for loading the molasses into tankers are not available, the alternative course would be the manufacture of raw sugar. If

cluding harbor facilities and ports, see sections under Domestic Commerce and under Water Transport in the Civil Affairs Handbooks.)

The following statements may be of some assistance to those who, with little or no previous experience, are faced with the problem of purchase and storage of copra. The quality of copra varies considerably, depending on content of moisture, extent of deterioration, and color. Good quality copra is made from ripe coconuts. It should be dry, clean, and free of mold and decay. Copra made from unripe coconuts is of poor quality and low oil content. The coconut meat is approximately half water and starts deteriorating as soon as it is exposed to the air. Copra is dried as promptly as possible to prevent the formation of mold and decay. Fully dried copra will have a moisture content of approximately 6 percent. Copra placed in storage will have a maximum moisture content of 8 to 10 percent. Deterioration can be expected if the moisture content is 12 percent or more.

Judgment as to the quality of copra can be gained only with experience. Rotten copra should not be accepted at all, of course. The principal factor in price is the moisture content and the absence or presence of mold. Rough and ready methods of determining dryness include such practices as kicking a bag and noting the sound, or breaking pieces of meat. The crispness or dullness of the sound given when a bag of copra is kicked is a measure of dryness, as for a bag of leaves. A wet piece of copra will bend rather than break, but a fully dried piece will snap. An experienced buyer may depend entirely on such methods.

When received, if copra is not properly dried, it should be spread out and turned frequently until dry. After being properly dried, copra should be stored loose (not in sacks) in a dry place, where it will keep for several months without much deterioration. A storage place should give full protection against rain, at the same time allowing for ventilation. Leakproof godowns open for 3 feet at the bottom and top are recommended; but some variation can be allowed, depending on circumstances. Where rain can be kept out, it may not be necessary to close more than one or two sides. If copra becomes wet during storage, deterioration sets in. Copra kept in storage will lose a certain amount of moisture, and allowance for shrinkage should always be made when it is shipped out of storage.

Copra is commonly regarded as an unpleasant cargo to handle because of its smell and the possibility that worms will come out and infest the holds. While it can be shipped in bulk, such cargo is very slow in handling and leaves a very dirty condition in a ship. The better way is in sacks. A certain amount of shrinkage must be expected on a voyage and care must be taken to use chutes, ventilators, and dunnage in order to preserve a current of air in the copra cargo.

II. SUGAR AND SUGARCANE LAND

1. THE PROBLEM

A well-developed sugar industry has been established by the Japanese on several islands of the Marianas group. When control of these islands passes out of Japanese hands, the industry will automatically cease functioning. The important problems then will be: (1) what should be done with the industry itself; and (2) what use should be made of land formerly in sugarcane that may become available for other agricultural purposes. (See OPNAV 50E–11.)

2. THE SITUATION

***a.* The sugar industry.**—According to reports, a small amount of sugarcane has been grown on a number of islands for the manufacture of alcohol or for local consumption as cane. Sugarcane for the production of sugar on a commercial scale, however, has been grown only on the three islands of Saipan, Tinian, and Rota. Mills with modern equipment have also been established on these islands for the manufacture of raw sugar, which subsequently was shipped to Japan to be refined. The average yields of cane on Rota have always been comparatively low; and it is reported that the sugar mill on that island closed down after 1939. Occupation, therefore, probably will find sugar manufacture and the largest acreage of sugarcane confined to the two islands of Saipan and Tinian.

The manufacture of alcohol was an important subsidiary industry. Plants for the manufacture of intoxicating liquors have been reported officially on Ponape, Truk, Palau, and Yap, as well as on islands of the Marianas. It is presumed that the alcohol used by some of these industries was manufactured elsewhere; but in other cases, as on Ponape, it was produced locally. Formerly alcohol in large quantity was produced only on Saipan and Tinian; but reports indicate that, more recently, large-scale production has also begun on Rota.

***b.* Production statistics.**—The following data, taken from *The Sato Keizai* (Sugar Journal), October

FIGURE 13.—Truk Islands. Udot Island. Simple unenclosed copra drying shed.

nut is cut from the tree, the husk is usually, though not always, removed. The coconut is then halved with a heavy bolo, and the halves are spread out to dry. Drying quickly loosens the meat from the shell. It is then removed with a knife and spread out for further drying. In Guam and elsewhere, the meats are spread out on mats to dry, the native folding up the mat and carrying the copra inside his hut when rain approaches. On the mandated islands, the Japanese encouraged the construction of small unenclosed drying establishments, covered with a corrugated iron roof. Trays are arranged inside to hold the coconut meat. The iron roof offers protection from rain. Also, as it absorbs the sun's rays, it increases the heat available for drying. In Ponape, and to some extent elsewhere, where the sunshine is not sufficient to dry copra quickly, fires are built under the racks.

Some modification of this method may still be the best means of drying the coconut meat on a small scale. In all cases drying should be effected as quickly as possible. If it is not sufficiently dried there is danger of spoilage, but if fully dried, the product will keep well for several months. For marketing the dried product is usually placed in sacks.

Where drying facilities are not available, consideration might be given to the possibility of loading whole coconuts on barges and towing them to other islands where proper drying facilities are established. While unusual, this might be the most satisfactory method of handling the drying of coconut meat.

Planting coconuts.—The techniques of coconut cultivation are simple, but attention to several points will generally prove rewarding. First is the selection of seeds. The inherent ability of individual trees to produce varies greatly. Although it cannot be guaranteed that the progeny of any given tree will resemble the parent tree (because only one parent is known) nevertheless, nuts selected from high-yielding trees will on the average produce higher-yielding trees than unselected nuts. Nuts should be selected, not from a pile, but from those trees which, when growing under similar conditions, produce a better crop of nuts than neighboring trees. Trees producing a small crop of nuts, however large the individual nuts may be, and trees in especially favored spots although producing large numbers of nuts, should be avoided.

A second point of importance is the preparation of the seed for planting and the placing of the seed in the ground. Practices differ in these matters, and the advice of natives will usually provide the best guide in each place. Proper spacing should be emphasized. This is important because of a destructive scale insect, which is particularly destructive on weakened trees that inevitably develop with overcrowding. While this insect is often kept in control by parasites, which the Japanese have already introduced, it need be less feared when trees are kept healthy. Proper spacing also makes it easier to cultivate the trees and collect the nuts. Well-kept plantings of coconuts can be observed to learn what the recommended spacing distances should be.

***b.* Collection of copra.**—In working out a system of collection, suggestions may be found in the system formerly used by the Japanese. The copra, placed in sacks, was collected in the first instance by traders. In the Marshalls in 1932, 69 trading centers were reported to exist, usually run by a Japanese merchant and his family. The merchant, who commonly acted as agent for the Nanyo Boeki Kaisha, generally kept on hand a stock of cheap Japanese trade goods, including tools, utensils, and sundries, as well as tinned goods, flour, and rice. According to reports, the proceeds were divided among the producer, the headman of the village, and the chief. One report stated that, of 8½ sen paid per kilo of copra, 4 sen went to the chief, the headman receiving one-third and the producer two-thirds of what remained. Receipts were given the producer, the stubs being turned over to the chief. Cash or barter goods were given to the producer and headman on the spot, but accounts were settled later with the chief or his business agent. Traders were strict about quality; and a bonus of 2 yen was paid to the producer for every ton completed, to encourage quantity production. The pattern in other places appears to have been similar.

Collection from these island trading centers was made by the Nanyo Boeki Kaisha, which operated boats between the principal island and adjacent islands of each of the main groups. The principal centers were: in the Marshalls, Jaluit; in the east Carolines, Ponape and Truk; in the west Carolines, Yap; and in the Marianas, Saipan. Ships used on these runs were sailing vessels equipped with auxiliary engines, or small steamers. It is reported that the two vessels used within the Marshall Islands were a steamer of 540 tons and a sailing vessel of 192 tons.

From these collecting centers the material was shipped to Japan in steamers of the Nippon Yusen Kaisha, which operated four lines from Kobe to different points in the mandated area. Tonnages of the vessels employed on these runs varied from about 3,000 to over 6,000. (For more complete information with regard to inter-island trade and shipping, in-

B. AGRICULTURAL PROBLEMS

I. COCONUTS AND COPRA PRODUCTION

1. THE PROBLEM

Coconuts are raised on islands of all the major groups in the mandated area. While traditionally an important item of food in the native diet, the coconut owes its importance recently more to the world demand for copra, its dried meat. This commodity is particularly important at the present time because coconut oil, extracted from copra, is one of the essential war materials of which there is a shortage. It is also of basic importance to the native economy, because it is the chief source of income of a large part of the population.

The problem upon occupation will be to find ways of rehabilitating this industry, and of collecting and shipping the product to centers where it can be utilized.

2. THE SITUATION

***a.* Statistics.**—It is estimated that the total amount of copra produced in the mandated area in 1937 was approximately 17,000 tons. Table 6 summarizes the available data on coconut-palm acreages and copra production.

TABLE 6.—*Coconut-palm acreages and copra production*

	Coconut palms		Copra	
	Acres	Producing trees	Production (short tons)	Export (short tons)
Marshall Islands (1938)	28,400		6,389	
East Carolines (1937):				
Ponape district:				
Government owned plantations	8,133			
Privately owned plantations	10,664			
Total	18,797	685,376	3,578 (1938)	
Truk district (1937):				
Government owned plantations	40			
Privately owned plantations	10,428	432,237		
Total	10,468	1,117,613		
Total, East Carolines	29,265			
West Carolines (1937):				
Yap district	8,278	322,223		
Palau district	4,878	167,357		
Total	13,156	489,590		1,153
Saipan district (1937):				
Government owned plantations	5,330			
Privately owned plantations	1,754			
Total	7,084		750	
Guam (1939)	12,000			2,500
Grand total	89,905			

***b.* Outlook for copra in the future world markets.**—The current acute shortage of copra may be expected to end when supplies again become available from large producing areas, such as the Philippines. A strong demand for this product, however, is expected to continue for a year or two after the war ends. After that prices may fall, but since the industry is largely on a native basis, with little outlay except in time, it ought to provide a significant source of income to the natives even in bad years.

***c.* Effect of the war on copra production.**—Field reports indicate that in the Marshall Islands copra was not purchased after the middle of 1942. Since, aside from sale, there is no incentive to produce copra, it may be expected that subsequently little or no copra was produced. A similar suspension of copra production has probably occurred in other areas of the mandated islands; and therefore it is not to be expected that large stocks of copra have piled up. Ripe coconuts, however, should be available for drying, since coconuts ripen the year round, and in places drying might begin almost at once. Where fighting has been intense, coconut trees have been seriously injured or destroyed by direct military action. It may be expected that drying establishments, as well as knives and copra bags, have been damaged or lost.

3. ALTERNATIVE COURSES OF ACTION

***a.* Rehabilitation of the industry.**—*Copra production.*—Although some copra was produced on a large scale, the majority of the copra has been produced on a small scale by native growers. The process native growers use is a simple one. After the

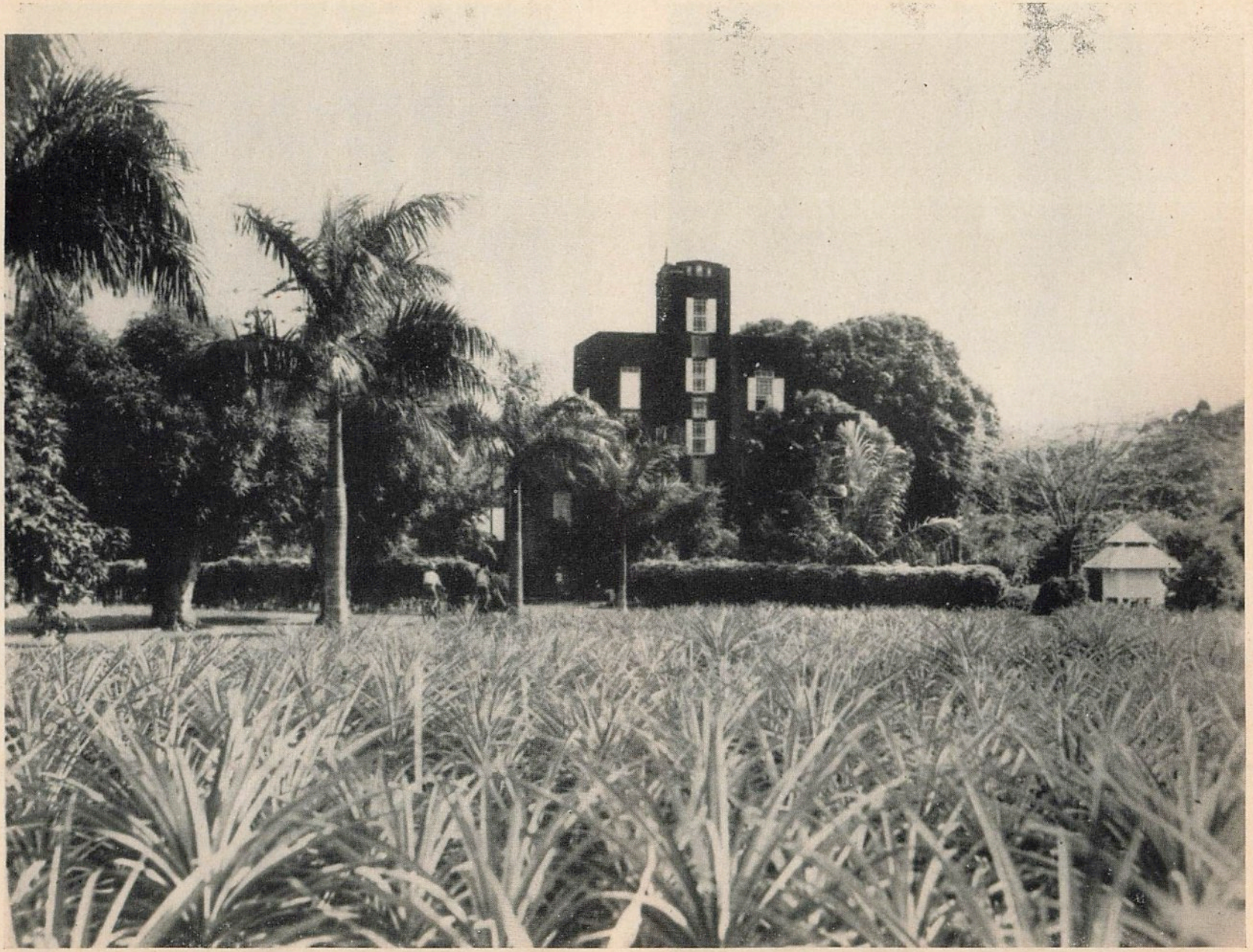


FIGURE 12.—Ponape Island. Government experiment station (1935).

FIGURE 10.—Palau Islands, Babelthuap Island. Colonist farm, the crop probably pineapple.

FIGURE 11.—Marianas Islands, Tinian Island. Typical intensive sugarcane cultivation (1944).

FIGURE 8.—Guam. Sumay.

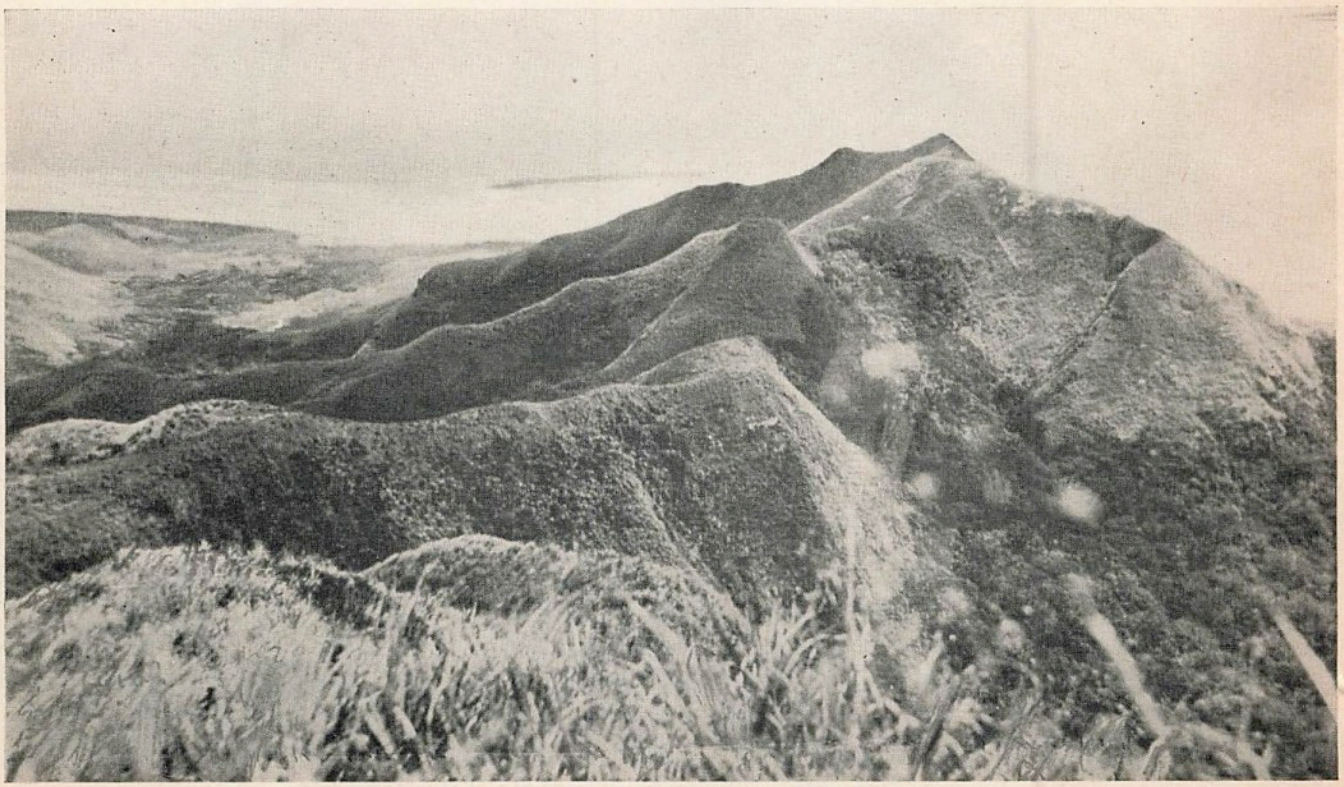


FIGURE 9.—Guam Island. Schroeder Mountain (1935–37).

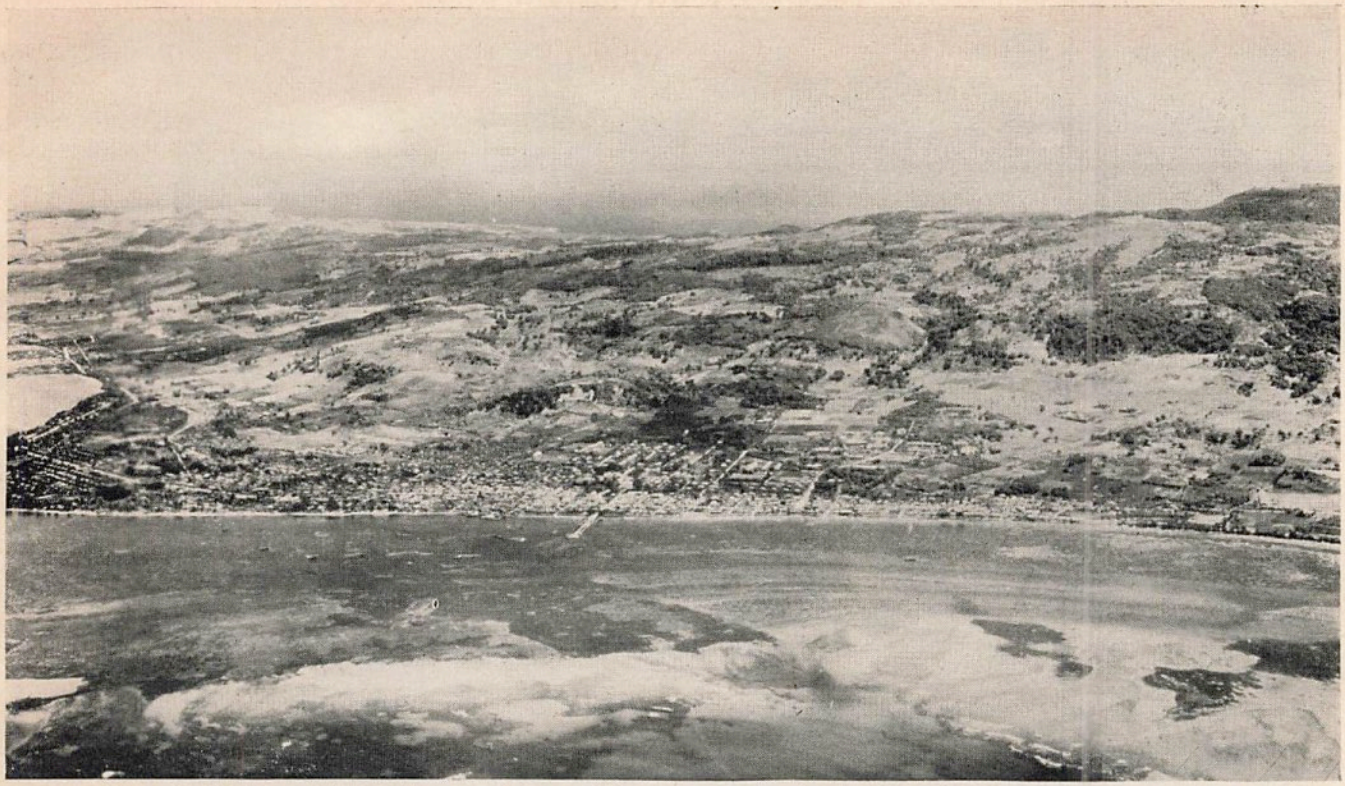


FIGURE 6.—Marianas Islands. Saipan. Garapan, with rougher terrain of volcanic formation in the background (1944).

FIGURE 7.—Ponape Island. Basalt rock, south central part of Jokaj district.

FIGURE 5.—Marianas Islands, Saipan. General view from southern tip—sugarcane fields and farmhouses on limestone terraces. Mount Tapotchau (volcano formation) in left background (1944).

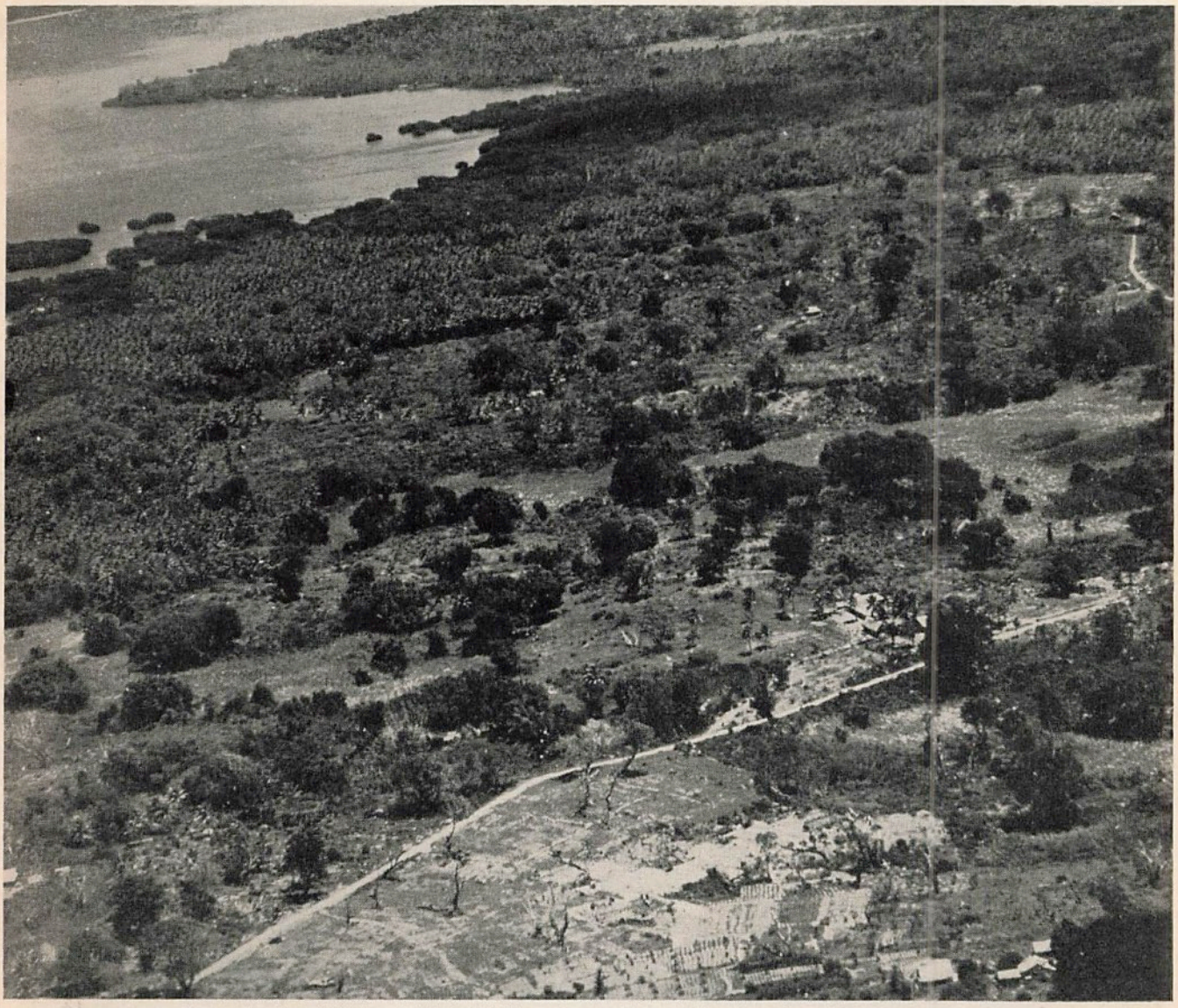
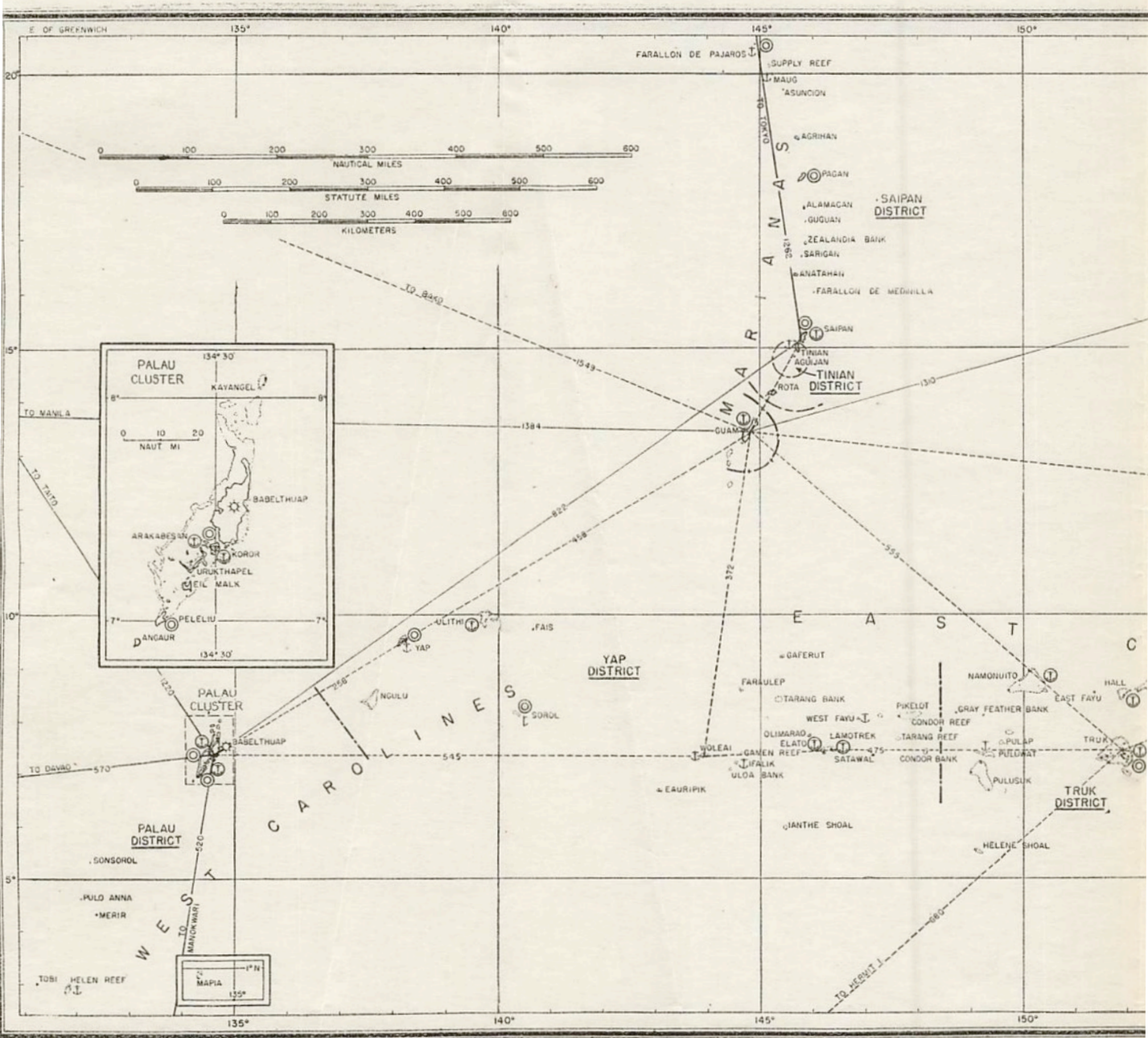


FIGURE 2.—Yap Islands. Cultivated fields and natural vegetation of southern Rull Island (1944).



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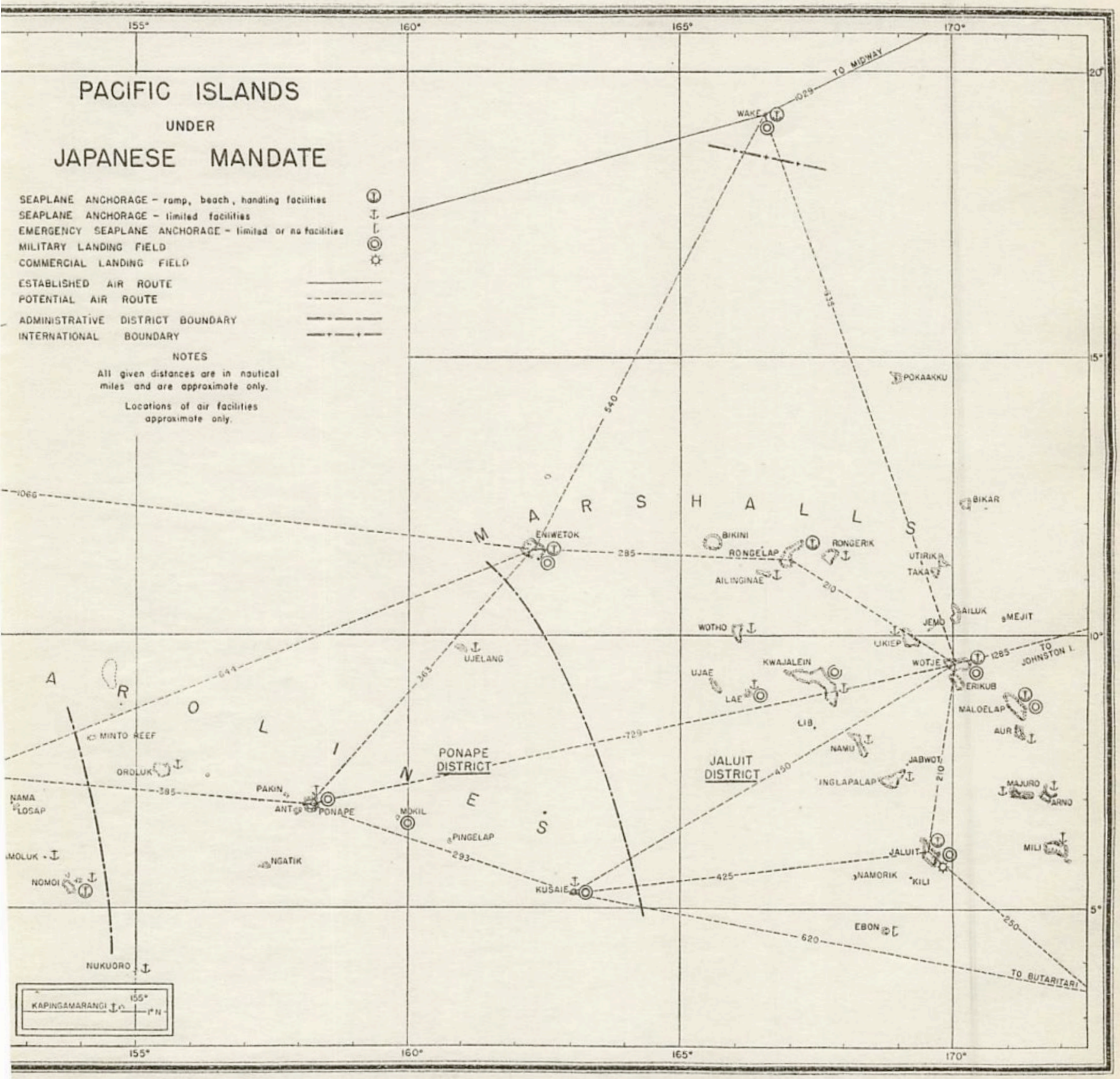
PACIFIC ISLANDS
UNDER
JAPANESE MANDATE
SEAPLANE ANCHORAGE - ramp, beach, handling facilities
SEAPLANE ANCHORAGE - limited facilities
EMERGENCY SEAPLANE ANCHORAGE - limited or no facilities
MILITARY LANDING FIELD
COMMERCIAL LANDING FIELD
ESTABLISHED AIR ROUTE
POTENTIAL AIR ROUTE
ADMINISTRATIVE DISTRICT BOUNDARY
INTERNATIONAL BOUNDARY
NOTES
All given distances are in nautical miles and are approximate only.
Locations of air facilities approximate only.
155°
160°
165°
170°
20°
15°
10°
5°
TO MIDWAY
1029
WAKE
540
M A R S H A L L S
C A R O L I N E S
ENIWETOK
285
BIKINI
RONGELAP
RONGERIK
AILINGINAE
UTIRIK
TAKA
POKAAKKU
BIKAR
AILUK
MEJIT
JEMO
UKIEP
WOTHO
UJELANG
UJAE
LAE
KWAJALEIN
WOTJE
ERIKUB
1285
TO JOHNSTON I.
MALOELAP
AUR
LIB
NAMU
JABWOT
INGLAPALAP
JALUIT DISTRICT
PONAPE DISTRICT
MAJURO
ARNO
MILI
JALUIT
KILI
NAMORIK
EBON
KUSAIE
MOKIL
PINGELAP
PONAPE
PAKIN
ANT
NGATIK
ORoLUK
MINTO REEF
NAMA
LOSAP
NOMOI
NUKUORO
KAPINGAMARANGI
1°N
1066
644
363
729
385
293
450
425
620
250
210
TO BUTARITARI

Tomatoes.—Only limited success has been obtained with tomatoes, and it is recommended that plantings be limited to the lowlands except where irrigation water is available. No specific recommendation has been made as to variety. Seed should be planted in seedbeds the last half of November and transplanted to the fields when 6 to 8 inches high.

Turnips.—Turnips do not usually grow as well as in the United States, but good quality turnips can be obtained by picking when of medium size, before they become pithy. They should be planted in November and December. The variety recommended is Purple Top White Globe.

Other vegetables.—String beans, Lima beans, peppers, radishes, beets, carrots, Swiss chard, collards, and eggplant have all been grown with success in Guam. The planting season for these vegetables is the same. For a crop during the summer, seed should be planted in June. For fall and winter use, planting should be done in September and subsequently to December or January. The following varieties have been recommended:

String beans.—Kentucky Wonder (especially productive).

Lima beans.—Henderson's Dwarf Bush.

Peppers.—Ruby King.

Radishes.—Cincinnati Market, White Icicle, Early Scarlet Globe.

Swiss chard.—Variety not stated.

Carrots.—Oxheart.

Beets.—Variety not stated.

Eggplant.—New York Improved (or local variety).

Fruits.—Of the fruits which are grown in the Marianas Islands, only pineapples mature quickly enough to warrant attention if a crop is desired in the period immediately following occupation. In Guam, pinapples are usually planted on upland soil, during the rainy season. Slips for planting may be obtained from plants already in local use, or from Hawaii. The fruit is harvested around eighteen to twenty months after planting. If plantings of papaya are considered, the Solo variety, a small variety from Hawaii stated to be of much better quality than the local variety, is recommended. The papaya is grown from seed and should be planted on the uplands.

Planting practices.—In preparing the land for planting, as well as in the actual planting and subsequent handling of the crop, certain special practices may need to be observed. It would be of interest to find out, for instance, whether raised beds, paralleled by drainage ditches, are employed for any crop. It might be important to know, also, what is normally done to insure the germination of fine-seeded crops. Attention has been called in another section to the value of employing native foremen or experienced gardeners who are familiar with such details. These should be fairly easy to obtain on Guam. The Commissioners in office when the Japanese took this island might be able to recommend suitable persons. It is reported, also, that about 60 graduates of the agricultural school on Guam have entered the Navy, and that some of these might be suitable to manage laborers.

Although not applicable to all situations, the following planting specifications given for Guam are suggestive.

PLANTING SPECIFICATIONS GIVEN FOR GUAM

[Source: Briggs, Glen. Vegetable Growing in Guam. Guam Agr. Sta. Bulletin No. 2, 1922]

Kind of vegetable	Seeds or plants required for 100 feet of row	Distances for plants to stand			Depth of planting
		Rows apart		Plants apart in rows	
		Animal cultivation	Hand cultivation		
Arrowroot	50 to 60 plants	3	3	1½-2	2-6
Beans:					
Kentucky Wonder	½ pound	3	1½	½	1-1½
Lima	¾ pound	3	1½-2	½	1-2
Frijoles	½ pound	3	1½	½	1-1½
Seguidillas	¼ pound	3	3	3	1½
Cerebillas	½ pound	3	3	3	2
Beets	2 ounces	3	1½	⅓	½
Cabbage	35 plants	3	3	1½	2-6
Calabaza	¼ pound	6-10	4-10	4-10	2
Carrots	½ to 1 ounce	2½	1-1½	½-¾	½
Cassava	25 cuttings	4	4	4	4-6
Chard	1 ounce	3	1½	½	1
Collards	¼ ounce	2½-3	1½	1½	1½
Cucumber	½ ounce	5	5	5	½
Eggplant	35 plants	3	3	3	2-6
Lettuce	100 to 120 plants	3	1½	½-1	1-3
Do	½ ounce	3	1½	1½-¾	1
Muskmelon	½ ounce	5	5	5	½
Mustard	¼ ounce	2½	1½	½-¾	1
Okra	1½ ounces	3	3	1½	2
Onion	1 ounce seed; 200 sets	2½	1½	½-½	1
Papaya	10 plants	10	10	10	6-12
Parsley	¼ ounce		1½	½-¾	1
Peppers	⅛ ounce seed	3	1½-2	1½	1
Do	65 plants	3	1½-2	1½	2-4
Pumpkin	¾ ounce	6	6	6	2
Radish	1 ounce		1½	½-2	1
Spinach	1 ounce		1½	½-¾	1
Squash	½ ounce	4	3	3	2
Sweet corn	¼ pound	3½	2½	3	2
Sweet potatoes	65 to 100 cuttings	4	3-4	1-1½	4
Taro	25 to 50 cuttings	4	2-4	2-4	3-6
Tomatoes	⅛ ounce, 30 plants	3-4	3	3	2-6
Turnip	½ ounce		1-1½	¼	1
Watermelon	1 ounce	6	6	5-6	1
Yam	35 cuttings	4	3	3	6

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