CIVIL AFFAIRS GUIDE

The Sugar Industry of the Japanese Mandated Islands

OPNAV-P22-103

(Formerly OPNAV-50E-11)

OFFICE OF THE CHIEF OF NAVAL OPERATIONS

NAVY DEPARTMENT

18 MAY 1944

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1. Restricted. OPNAV 50E-1. Military Government Handbook. *Marshall Islands*. 17 August 1943.

2. Restricted. OPNAV 50E-2. Military Government Handbook. *Kurile Islands*. 1 November 1943.

3. Unclassified. OPNAV 50E-3 (FM 27-5). United States Army and Navy *Manual of Military Government and Civil Affairs*. 22 December 1943.

4. Unclassified. OPNAV P22-102. Civil Affairs Handbook. *Administrative Organization and Personnel of the Japanese Mandated Islands*. 1 January 1944.

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

6. Confidential. OPNAV 50E-6. Civil Affairs Guide. *Population and Economic Problems during United States Naval Occupation of the Marshall Islands*. 6 January 1944. Temporarily withdrawn.

7. Restricted. OPNAV 50E-7. Civil Affairs Handbook. *West Carolline Islands*. 1 April 1944.

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9. Restricted. OPNAV 50E-9. Civil Affairs Handbook. *Bonin Islands*. To be released in May 1944.

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The Sugar Industry of the Japanese Mandated Islands

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(Formerly OPNAV-50E-11)

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OCCUPIED AREAS SECTION

OFFICE OF THE CHIEF OF NAVAL OPERATIONS

NAVY DEPARTMENT

18 MAY 1944

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LETTER OF PROMULGATION

OFFICE OF THE CHIEF OF NAVAL OPERATIONS,
NAVY DEPARTMENT,
WASHINGTON 25, D. C., *18 May 1944.*

CIVIL AFFAIRS GUIDE

THE SUGAR INDUSTRY OF THE JAPANESE MANDATED ISLANDS

OPNAV 50E–11

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F. J. HORNE,

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

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1. Sugarcane has been grown by native islanders of the Central Pacific for decades, but commercial sugar production began only with Japanese occupation during World War I.

2. Sugarcane acreage increased from approximately 100 acres in 1916 to 1,100 acres in 1920 and to over 30,000 acres in 1938, located entirely in Saipan, Tinian, and Rota in the lower Marianas.

3. Sugar production in recent years has ranged from 139 to 164 million pounds, approximately 3 to 6 percent of Japanese Empire production, and a fraction of 1 percent of production available to the United States. Sugar constituted over 50 percent of exports from the Mandates.

4. The sugar industry has developed and continues to operate under the direct monopoly control of Nanyo Kohatsu Kabushiki Kaisha.

5. Labor in mills and plantations is almost entirely Japanese.

6. Some few independent cultivators grow cane under direction of the company—independent native planters control only 1 percent of total cane acreage.

7. Sugarcane is harvested and ground during the dry season, which extends approximately from December through May.

8. Narrow-gage railroads connect plantations with sugar mills.

9. Sugar mills are of relatively modern design, operating according to generally approved efficient methods.

10. Alcohol is manufactured from molasses, a byproduct of sugar production. Alcohol is shipped to Japan, although some is used in the islands for liquor.

11. The sugar industry has operated with subsidies for clearing land, plantations, milling, and shipping.

12. Other food crops, for subsistence of workers and for export to Japan, are grown on the islands.

II. THE MARIANAS

SAIPAN

1. The sugar industry first began on Saipan. Approximately 9,500 acres of cane were grown there in 1938 in three plantations.

2. Fifty-three miles of narrow-gage railroad connect plantations, mills, and towns. Highways are fair to poor.

3. A large sugar mill with a capacity of approximately 1,200 tons per day is located at Charan-Kanoa, about 4½ miles south of the town of Garapan.

4. Approximately 340,000 gallons of alcohol were made from molasses on Saipan in 1936.

5. Bagasse is used for fuel in the Saipan mill, as also in mills on Tinian and Rota. An excess of bagasse over sugar milling requirements probably is available for operating distilleries, or other purposes.

6. Eight warehouses for storing raw sugar are located on Saipan.

7. Cassava (tapioca) also is an important commercial crop on Saipan. Other food crops also help supply natives and colonists.

TINIAN

8. Cane planting on Tinian approximated 14,800 acres in 1938, the largest cane acreage of the three sugar-producing islands.

9. Forty-nine miles of narrow-gage railroads connected plantations and mills in 1936. Roads are poor.

10. Two mills, with a capacity of 2,200 tons of cane per day are located close together near Tinian Town (Sunharon).

11. Alcohol production on Tinian approximated 430,000 gallons in 1936.

12. Warehouses surround the mills for storage of raw sugar.

13. A few other crops are grown on Tinian, but the acreage is very small.

ROTA

14. Sugarcane production was begun on Rota considerably later than on Saipan and Tinian. Cane acreage in 1938 approximated 6,200 acres.

15. 22 miles of narrow gage connect plantations and mills.

16. Mills are located near the southern end of the island.

17. No quantitative data on alcohol production is available, although some probably is produced on the island.

18. Warehouses are located at mills.

19. Other food crops for subsistence are grown.

OTHER ISLANDS

20. Sugarcane has been reported at various times on Aguijan and Agrihan but such reports remain unconfirmed.

III. THE CAROLINES

PONAPE

1. Sugarcane acreage is very small.

2. Other crops are more significant. Cassava (tapioca) is the most important commercial crop, followed by copra, breadfruit, and sweetpotatoes. Tropical fruits and vegetables are important for subsistence of natives and colonists.

3. A large and important agricultural experiment station is located on Ponape. Its relationship to the agricultural economy of the islands has been direct and beneficial. Many valuable plants have been adapted to the islands.

KUSAIE

4. No cane is grown; however, other edible fruits and vegetables do well and have been developed.

5. An experimental farm is reported on Kusaie.

TRUK

6. No cane is grown commercially on Truk. Other edible crops are grown for subsistence.

7. An experimental farm is reported here.

PALAU

8. Cane acreage, if any, is small.

9. An extensive experimental farm is known to be on Koror Island.

IV. AGRICULTURAL EXPERIMENT STATIONS

1. Agricultural experiment stations, located on each of the larger islands—Ponape, Truk, Kusaie, Saipan, Palau, and Yap—are most important factors in the agricultural economy of the islands.

2. Many plants have been adopted for use by the natives and colonists.

3. Salvaging results of scientific work and expense represented by experiment farms would contribute to the future agricultural economy of the islands.

V. COURSES OF ACTION

1. The outlook for the Mandates' sugar industry in a competitive world market is not bright.

2. Sugar production is important primarily to Japanese colonists, although some few natives produce cane. For the latter, consideration may be given to extending their part of the industry to supply local needs.

3. Labor for continuing the sugar industry at its present levels will present a difficult, if not impossible, problem. Labor available for work in fields may be considered for production of subsistence crops.

4. Damaged mills may be inspected and an estimate made of the possibility of reassembling a small mill from salvaged equipment and material.

5. Should it be undesirable or inexpedient to reestablish a small mill from salvaged equipment, primitive mills which natives can operate may be an alternative course of action.

6. A lapse in sugar production would not seriously damage cane fields. Cane will continue growing and may be harvested later.

7. Demand for fresh produce by natives, captives, and occupying forces, may make it advisable to convert land and labor from cane to fresh vegetables and other produce.

8. Consideration may be given to salvaging the work of agricultural experiment stations for the benefit of the agricultural economy of the natives, the occupying forces, and the continuing government of the islands.

9. Salvage of equipment in the mills might be undertaken in the early stages of occupation in order to establish temporary sources of power.

II. GENERAL

Sugarcane is indigenous to the larger volcanic islands of the mandated group, but natives raised little prior to the Japanese occupation. Only small areas were devoted to its cultivation and production was conducted along primitive lines. Sugarcane produced by the natives was for their own use, not for commercial purposes. With the advent of the Japanese during World War I, commercial sugarcane production was begun. Insofar as the soil and climate were conducive to the growth of sugarcane, it was readily adaptable to the Japanese scheme of strategic and economic exploitation of the islands. Also the Japanese Empire was, until the late twenties (1929), a sugar-deficient area.

Colonial development of sugar production increased rapidly during the twenties in Taiwan as well as in the South Seas, as also in Japan proper. Sugarcane production is reported (Teiso Esaki, 1940) as the most important agricultural activity in the South Sea Islands. Esaki reports also that the large plantations are restricted to the Marianas—Saipan, Tinian, Aguijan, and Rota—with small plantations in Ponape for alcohol production. Other literature implies some cane may be grown for commercial purposes on Kusaie, Truk, Palau, Yap, and Agrihan. However, most reports indicate that attempts to grow cane commercially on Kusaie and Truk did not prove successful and that it has been abandoned.

In addition to sugarcane, the Japanese colonists also grow commercial quantities of cassava or taro, coconuts, papayas, coffee, cotton, bananas, and vegetables. Each colonist was given a garden plot for vegetable production, presumably for household use. Household production tends to relieve imports of foodstuffs. An integral part of agricultural policy for the mandated islands was the experimental farm or station where plants of commercial import were adapted to local soils and climate. Experimental farms are reported on each of the important volcanic islands. This policy enabled the colonists to become more self-sufficient in locally grown food. A radio intercept (Domei, 24 Jan. 1944) indicates a shift in agricultural policy for the South Seas. A self-support program was instituted during 1943, according to this report, which involved conversion of some sugarcane lands to production of food products. There were no indications as to the extent of the conversion or the islands affected.

AGRICULTURAL LAND

Although virtually all the Japanese mandated islands, atolls as well as volcanic, support vegetation and produce some edibles, only the volcanic islands assume any significance agriculturally. In general, the volcanic islands rise from coral and flatlands at the shore to undulating rises inland, usually culminating in one or more peaks ranging from a couple of hundred to as much as over 2,000 feet in height. The strands or beaches usually are composed of fine coral sand especially well adapted to coconuts. Although the soils of the strand contain considerable organic matter, it usually is not of such a nature as to be readily decomposed, and therefore it is unsuitable for most plants. However, coconuts and other indigenous plant life have grown for ages in such areas without any noticeable loss of fertility. Marshes or swamps usually are found bordering the beaches at levels slightly above high tide. In such areas, the soil usually is relatively deep and black and contains considerable organic matter. Fertile tract. capable of successful cultivation may be found bordering upon swamps or more frequently in interior valleys. The soils in interior valleys or on the interior low tablelands provide the best areas for cultivation and commercial production. Usually on somewhat higher ground, raised platforms or mesas will be found which have a thin covering of soil often only a few inches in depth. These higher flatlands, although supporting some crops during the rainy season, usually do not have sufficient fertility to maintain agricultural growth for more than a few seasons. The underlying structure usually is a permeable calcareous soil which does not hold moisture. Higher on the peaks will be found rocky land which may support some forest growth, but usually it is not considered arable and seldom are attempts made at cultivation. The arable areas support various types

of vegetation but usually chemical fertilizers, particularly phosphates and potash, are necessary to maintain fertility after the first year or two of cultivation. The areas which are cultivated have been chosen presumably after inspection by officials of the South Seas Development Co., which has directed agricultural policy. Cultivated areas may be found in all but the higher lands, dependent upon local conditions which make for successful farming.

Commercial development of agriculture has been directed by the Japanese mostly to the lower Marianas (Saipan, Tinian, Rota, and Aguijan), although efforts to promote commercial crops have also received considerable attention in the Carolines (Ponape, Kusaie, and Truk) and Palau (Koror, Babelthaup, and Peleliu). In 1936, 63 percent of Saipan, Tinian, and Rota was estimated as arable, while 59 percent of the land was cultivated. Some overestimation may be involved, for the cultivated area was shown as greater than arable area for Rota. The total cultivated area for Saipan, Tinian, and Rota was estimated as of 1936 at slightly over 44,000 acres. This does not seem unreasonable inasmuch as over 28,000 acres of sugarcane were reported for that year in the three islands. Coconut plantings probably are also included in the cultivated area which, when combined with sugarcane acreage, takes up the major portion of the areas shown under cultivation. Garden plots and other commercial acreage, such as cassava, probably take up most of the balance.

SUGARCANE ACREAGE

In 1916, only 20 hectares (approximately 50 acres) were planted to sugarcane in the Mandates. By 1919, plantings had increased to 459 hectares (1,104 acres). A sharp upward trend in sugarcane acreage continued with over 30,000 acres reported under cultivation in 1938 (table I).

TABLE I.—*Area under sugarcane*

Year	Saipan	Tinian	Rota	Total
	Acres	*Acres*	*Acres*	*Acres*
1919–20				1,104
1922–23				4,033
1925–26				6,632
1928–29				7,980
1929–30				11,043
1930–31				14,781
1931–32				15,978
1932–33	8,588	7,073		15,661
1933–34	7,905	6,696		14,601
1934–35	7,719	12,606	3,688	24,013
1935–36	9,188	14,211	4,771	28,170
1936–37	9,126	14,373	4,848	28,347
1937–38	9,413	14,800	6,187	30,400

Table I includes the most important sugarcane areas in the mandates, although there probably is other commercial acreage. Some cane production is reported (1940) by the entomologist Esaki on Aguijan, also on Ponape for alcohol production. No separate figures are shown in available reports for Aguijan, but they may be included with Tinian which is only 5 miles distant or Saipan, 20 miles away. Also there are no indications of a sugar mill on Aguijan, hence cane grown there most probably is crushed on Tinian, or less probably, on Saipan. Cane production is also reported on Agrihan but no quantitative data concerning it can be found.

Official Japanese reports to the League of Nations as late as 1936 show liquor manufacturing plants as follows: Saipan 13; Palau 2; Truk 2; Ponape 3; and Yap 1. Alcohol is produced on Saipan. The presence of liquor plants, unless they are merely rectifiers, on the other islands implies strongly that some cane is grown there as that would be a better and more economical raw material than other possibilities, such as root starches. However, the acreage, if any, for these other islands is not known at present.

No reports are available on cane acreage since 1937–38. Since then there has been a decline in sugar production, which may be correlated with acreage, but which may also be the result of decline in yields per acre. Some decline has taken place during the war as sugarcane acreage has been converted to production of subsistence food crops.

YIELDS

Yields of cane per acre in the Mandates compare favorably with many other producing areas, such as Louisiana, Florida, Puerto Rico, Cuba, and the Philippines. They run considerably less than Hawaii.

Data for the years 1930–37, inclusive, show that cane yields in the mandates averaged 27.1 tons per acre, ranging from 17.4 to 29.3 tons per acre. Comparisons with other areas are shown in table II.

Yields vary among the islands. In 1937 they were as follows:

	Tons per acre
Saipan	25.9
Tinian	28.6
Rota	11.2

Larger cane acreage and higher yields per acre in Tinian than in Saipan and Rota imply that it is better suited to cane production. This is supported also by the rate of increase in acreage in Tinian.

Variations from year to year in yields may be attributable to difference in weather. Variations among the islands probably are due to differences in soil, although the low yield in Rota, as compared with Saipan and Tinian, may reflect relatively new plantings as well. However, new plantings in general should produce better the first few years than later unless proper chemical fertilization is followed. It is probable that both phosphates and nitrates are applied to cane fields to maintain yields at the tonnages shown.

TABLE II.—*Yields per acre*

	Yield per acre	Range
Japanese mandated islands:	*Tons*	*Tons*
1930	22.2	
1931	28.5	
1932	27.7	
1933	28.9	
1934	29.3	
1935	24.9	
1936	17.4	
1937	24.2	
Average, 1930–37	27.1	17.4–29.3
Louisiana, 10-year average (1930–39)	17.0	13.2–21.7
Florida, 10-year average (1930–39)	31.8	22.3–36.3
Puerto Rico, 10-year average (1930–39)	26.1	22.7–28.6
Cuba, 10-year average (1930–39)	17.2	13.4–23.1
Philippines, 10-year average (1930–39)	16.5	12.8–19.9
Hawaii, 10-year average (1930–39)	57.8	59.1–70.1

SUGAR PRODUCTION

Sugar production in the mandates followed a trend similar to cane acreage. Notable increases occurred in the 1930's (table III).

Although sugar production in the mandates increased appreciably, still it constituted but a small percentage of total production in the Japanese Empire—not more than 4 to 6 percent in most recent years. In turn, total sugar production from the Japanese Empire (table III) represents only an insignificant percentage of total world production. Also, sugar production in the mandates of 135 to 165 million pounds is only of minor importance to the United States compared with the 16 billion pounds produced in the continental United States and the principal areas supplying the United States with sugar. Philippine production for the 10-year period, 1930–39, averaged 2.3 billion pounds per annum; Hawaiian production for the same period averaged 1.7 billion pounds of refined sugar. Pending reoccupation of the Philippines and reestablishment of its sugar industry, sugar from the mandates, if it could be produced, should prove a useful supplement to the United States and allied supplies.

TABLE III.—*Sugar production*

Year [2]	Japanese Empire [1]					World [4] production	Mandates as percent of Japanese Empire
	Formosa	Japan proper	Hokkaido	South Sea mandated islands	Total		
	1,000,000 pounds	*1,000,000 pounds*	*1,000,000 pounds*	*1,000,000 pounds*	*1,000,000 pounds*	*1,000,000 pounds*	
1931–32	2,181	218	54	92	2,545	58,954	3.6
1932–33	1,397	227	53	96	1,773	54,740	5.4
1933–34	1,426	205	51	99	1,781	58,424	5.5
1934–35	2,129	232	78	150	2,589	59,606	5.8
1935–36	1,989	262	68	108	2,427	64,260	4.4
1936–37	2,221	206	90	127	2,644	70,384	4.8
1937–38	2,182	227	92	164	2,665	69,934	6.7
1938–39	3,127	316	90	155	3,688	66,518	4.2
1939–40	2,497	249	55	136	2,937	71,318	4.6
1940–41 [3]	1,771	228	60	139	2,198	70,636	6.3

[1] Not including small amounts from Korea and Karafuto.

[2] Sugar year commences Nov. 1.

[3] Estimated.

[4] The World Sugar Situation, September 1943, Bureau of Agricultural Economics, United States Department of Agriculture.

Sources: (1) Field reports and despatches from the commercial attaché's office, Tokyo; also from Taihoku, Keijo, and Kobe. (2) Statistical data prepared by the Department of Agriculture based on the above reports and various Japanese publications.

IMPORTANCE OF THE SUGAR INDUSTRY TO THE MANDATES

The sugar industry, while of little benefit to the native economy, is the most important commercial development in the mandated islands. Raw sugar—the principal export commodity—is shipped from the islands to Japan proper for final refining and ultimate distribution. Exports of sugar in recent years have accounted for well over 50 percent of the value of total exports from the islands to Japan and have been three to four times as valuable as the next most important commodities—dried bonito, phosphate, and copra (table IV).

TABLE IV.—*Staple exports, inclusive of exports to other parts of the Japanese Empire*

[In ¥1,000,000]

Year	Sugar	Dried bonito	Alcoholic liquor	Nilotic-top shells	Alcohol	Phosphate	Copra	Total exports
1931	9.2	0.7	0.04	0.06	0.3	0.8	1.1	12.8
1932	9.6	.9	.1	.08	.4	1.1	1.2	13.8
1933	12.9	1.5	.1	.09	.4	1.4	1.5	18.2
1934	12.4	1.8	.05	.2	.5	1.4	1.1	16.5
1935	18.1	2.2	.07	.09	.6	2.2	1.8	23.7
1936	13.0	2.7	.1	.07	.8	2.9	2.0	25.0
1937	19.6	5.8	.2	.8	2.4	3.3	.01	37.9
1938	25.3	3.6	.1	.1	.8	8.1	3.0	45.3

Source: Japan-Manchoukuo Yearbook: Tokyo, 1940, p. 570.

Sugar consumption in the South Sea mandated islands is estimated at 3 million pounds for 1938 and 4 million pounds for 1939. Probably it is no larger, if as large, since 1940, despite possible population increases, due to a rather strict sugar-rationing program instituted by the home government applying, presumably, also to the South Seas.

ORGANIZATION OF THE SUGAR INDUSTRY

THE SOUTH SEAS DEVELOPMENT CO.

The sugar industry in the Mandates is under the direction and monopoly control of the South Seas Development Co. (Nanyo Kohatsu Kabushiki Kaisha). This company, with its subordinate affiliates, has recruited Japanese colonists principally from the Loochoo Islands; taken title to or rented land in the islands; cleared and developed land for agriculture; contracted with the colonists either as laborers, tenants, or independent farmers; provided seed and tools; built and operated sugar mills; procured cane both from its own lands as well as independent operators; and handled distribution of sugar, alcohol, and other exports from the islands to outlets designated by the home government. The company also manufactures alcohol as an integral operation within the sugar industry. Molasses, a byproduct of sugar manufacture, is used for distillation; it is probable also, that some cane juice goes directly to distilleries without any sugar extraction.

It should be noted, with emphasis, that the company fosters another activity in the islands directly related to agriculture, including sugarcane—the experiment station or experimental farm. Under the leadership of trained agriculturists and scientists, a variety of plant forms have been tried in the islands, many of which have been adapted to commercial or subsistence culture. The largest station is on Ponape, with others on Saipan, Kusaie, Yap, Pagan, and Palau (Koror). Not only have the experimental farms provided crops which can be grown there, but they also have been used as a training ground for colonists and natives, particularly the rural police, who then extend the benefit of their knowledge and cultural practices to other colonists and natives living on the land.

LABOR SUPPLY

The sugar industry is dependent almost exclusively upon Japanese immigrant labor. The natives either have not been recruited as sugar workers or have not proven satisfactory, although natives are largely used in the Angaur Island phosphate mines. Furthermore, the immigrants, largely from Loochoo Islands, are industrious and hard-working with some knowledge of agriculture.

Workers are employed on 1-year contracts, which are usually renewed for several years. Housing is provided, rent-free, and in addition a garden plot. Food is not furnished by the sugar company; laborers must purchase it themselves. It is estimated (1937) that a laborer's food costs from 7 to 15 yen per month. Laborer's wages were reported as approximately 1 yen per day, while wages ranged from 3.20 yen to 0.60, depending upon the nature of the work and the skill of the worker. An analysis of the labor force in 1937 shows:

TABLE V.—*Mandated islands, Labor force employed in the sugar industry, 1937*

Classification:	*Number employed*
Workers in refining plants, transportation of raw materials, and clerical work	4,520
Plantation workers under direct control	2,000
Tenant farmers	6,140
Independent Japanese farmers	210
Independent Native farmers	130
Total	13,000

INDEPENDENT CULTIVATORS

In addition to the plantations directly operated by the South Seas Development Co., Japanese tenant farmers, renting from the company, cultivate approximately 70 percent of the land devoted to sugarcane. In 1937 there were 2,555 families of tenant farmers with the total number laboring under tenancy arrangements estimated as 9,700 laborers. Land which has been cleared by the company is rented under contract usually for 3 years, with rental amounting to about 15 to 20 percent of the value of the crop. The rights and obligations of the tenants are determined by government regulations. The tenant is not free to use the land as he thinks best but must plant in accord with the direction and supervision of the company. Independent farmers also grow sugarcane but their number is relatively small (table V), comprising only 136 households in 1937, 41 of such households (130 persons) being native. The total area cultivated by independent farmers (1937) was 1,015 acres, of which only 232 acres were cultivated by natives. Independent native cultivators averaged 5.6 acres of sugar-

cane; Japanese independents averaged 8.2 acres. All such farmers were located in the Saipan district.

All sugarcane is purchased by the company. Tenant farmers and independent operators can sell cane only through the company. The company is required to buy all cane produced by tenants and independents, and at prices approved by the South Seas director.

TILLAGE AND CULTIVATION

Prior to planting in cane, arable land must be cleared of its native growth. Equipment and tools for this purpose are not definitely known, although insomuch as the company fosters development of this kind by subsidy, mechanical equipment such as tractors may be of some importance in this operation. It is more likely that the subsidies are paid to tenant farmers or laborers for clearing trees, brush, and stumps. In such work, an axe in the hands of a colonist probably constitutes the main tool. If oxen or water buffalo are available they may be used for piling timber and brush preparatory to burning. Stumps may be fired and burned, later to be dug out or pulled out by oxen.

Tillage and cultivation are carried on by relatively primitive means compared with American methods. Hand labor is the mode. Cattle or oxen are indispensable to cultivation and to transporting the ripe cane after it is cut. Oxen probably are used for final clearing of the land and preparing it for planting. The soil is prepared for planting by turning with a primitive beam and shovel type plow. This is not a moldboard plow of the American pattern, but merely a beam with a metal shovel attached which rips up the soil. Sometimes a metal strip is attached on the upright of the beam which turns the soil to some extent. This implement is drawn by an ox or buffalo. If no draft animals are available the soil is turned by hand. The following draft animals were reported in the Saipan district in 1936:

	Head
Cattle	4,845
Horses	44
Water buffalo	38

After plowing, the soil is harrowed or raked. An oriental type of harrow consists usually of a wooden beam 4 or 5 feet long through which are driven steel rods or teeth which project down to scratch and pulverize the soil which has been loosened by plowing. Such harrows are drawn by oxen.

When the fields have been plowed and harrowed, furrows are plowed a few feet apart. Cane cuttings, each containing an eye or bud, are dropped into the furrows, then covered with earth. Each eye or bud is capable of producing a new cane plant. The growing cane must be cultivated during the first few months to keep down weeds. Although mechanical cultivation is followed on Hawaii and Caribbean sugar plantations, such cultivation most probably is entirely by hand in the Mandates.

Sugarcane is a perennial and, under proper management, may produce two or more crops from the same planting. After the first cutting from the original planting, the ratoons, or new growth, are allowed to grow again, making another crop. This procedure may be repeated many times under proper management. The ratoons are allowed to grow in rows, the middles being cultivated or mulched with leaves from the previous cuttings. In due course, the ratoons become another crop of cane. Labor and other costs of replanting are saved by such plantation management.

For planting and cultivation, four tools are considered important: fushinosa, machete, gaichai, and paieni. The fushinosa is described by a Japanese authority as similar to a spade, with a blade about 1 inch thick and a handle 10 feet long. It is good for weeding and digging holes. It is probably similar to, if not practically the same as, the Fosiños used in Guam. The machete is a large straight-bladed, heavy knife, common to the tropics both in the Eastern and Western Hemisphere. A gaichai is a western style axe used for cutting wood and other similar purposes. The paieni is a kind of wooden rake, apparently similar to the bamboo rake. This enumeration would seem to indicate that cultivation and harvesting are largely hand operations, which presumption is supported by prevailing low labor costs.

HARVESTING

Cane is cut by hand. Laborers chop the stalk near the base with a machete. The leaves are then stripped leaving a bare stalk several feet long which is loaded on carts to be hauled to the narrow-gage siding. Leaves are allowed to remain in the field to serve as cover for the soil, fertilizer, and to some extent, as cattle feed.

Harvesting of cane is heavy work. In other cane-producing areas it is done by men; probably only adult male laborers do the harvesting in the mandates. The use of the machete makes it dangerous for children and women; hauling cane from rows to oxcarts

is also heavy work and probably too burdensome for women and children.

SEASONS

The lower Marianas have distinct wet and dry seasons. Rain is abundant from July to October, which is generally considered the rainy season. January to June is the dry season. Some years the dry season starts in December.

Conditions during the wet season are conducive to cane growth. However, fields are too wet and muddy for harvesting. Cane is bulky and heavy. It must be hauled by carts from fields to narrow-gage railway. Carts probably bog down in the mud making it impossible to get the cane out.

Cane cutting probably begins as soon as fields permit and the cane is considered ripe; that is, when it has a high sugar content. Planting usually is so arranged that cane reaches its optimum condition throughout the dry season when it can be cut and milled. Harvesting and milling probably continue, conditions permitting, throughout the dry season, or from January (sometimes December), through May.

The length of the growing season is not definitely known. Many unknowns, such as specific soil conditions, prevalence of plant diseases, organization of labor forces, requirements of other work, weather conditions, etc., are considerations in determining the planting period. In general, however, planting probably is done either at the end of the dry season or at the end of the wet season. Cane which is planted just before the wet season may, under favorable circumstances, be harvested during the latter part of the following dry season. It is possible, however, that it may not be harvested until the second dry season following planting.

TABLE VI.—*Precipitation: Guam* [1]

Month	Rainfall		
	Average amount	Number of rainy days	Maximum in 24 hours
	Inches		*Inches*
January	2.42	13	2.3
February	2.86	13	4.5
March	3.19	12	7.6
April	2.18	10	2.7
May	4.07	15	4.5
June	5.65	18	4.8
July	14.24	25	10.5
August	15.70	24	9.6
September	16.14	22	6.6
October	12.61	22	16.0
November	7.20	20	8.8
December	4.80	18	3.0
Total	91.06	212	

[1] Hydrographic Office. Proximity of Guam, Rota, Tinian, and Saipan brings them within the same weather belt.

Number of years observed, 23.

TRANSPORTATION

Sugarcane is bulky and heavy. Each stalk is cut by hand, then stripped of leaves, and either carried to rail sidings or, more probably, placed on oxcarts to be hauled to sidings.

Narrow-gage railroads are commonly used for hauling cane from plantations to sugar mills in commercial sugar-producing areas. The Japanese have built narrow gages for this purpose on Saipan, Tinian, and Rota. No indication of rail transportation for hauling cane has been noted on other islands. (More detailed description of transportation and its relation to individual sugar mills will be found under discussion for specific islands.)

SUGAR MILLS

Prior to Japanese occupation during World War I there were no commercial sugar mills in the mandated islands. What little cane was produced then was used for chewing by the natives. The Japanese, in developing sugar production as part of their colonial policy, not only planted cane but also built mills to manufacture raw sugar. The South Seas Development Co., as it increased cane production, built all the sugar mills now existing in the islands. Their engineers, therefore, had access to relatively modern sugar milling techniques in laying out and constructing plants. Their mills appear to be built along modern lines and they probably operate according to efficient techniques as used in other sugar-producing areas.

Assuming the mills are comparable with mills of similar size in other producing areas, the milling process generally would be along the following lines:

The cane is unloaded from cars by mechanical devices which may lift the cane from cars or hoist or dump it. In some instances the cane is raked or pulled from cars. The cane is unloaded or dumped from the cars on to conveyors, carriers, or elevators, which take it to the crushers and mills. Usually cane knives, whirling at high speed on a cylindrical shaft, operate on the cane carrier or elevator to reduce the size of the stalks and to even out the flow of cane to the crushers and mills.

Multiple mills are set up to crush the cane and extract the juice. These usually consist of a crusher or shredder and three or more three-roller mills. The crusher is designed to prepare the cane for milling by

breaking down the hard structure of the cane and extracting some of the juice. The crusher consists essentially of two shafts, with rough surfaces of either sharp corrugations or teeth, revolving in opposite directions and at different rates of speed. The cane is torn into shreds by the crushers; the cells are crushed; some juice is expressed, but mainly the cane is prepared for the mills which follow in tandem.

Each mill has three rolls. The bottom, where the cane enters, is termed the "cane roll," and that opposite the "bagasse" or "discharge roll." The two bottom rolls are usually rigidly fixed in position and the top roll is controlled by a hydraulic ram and is so arranged that it may rise and fall or "float" with variations in the feed of the cane. The crushed cane, now called "bagasse," is passed from one pair of rolls to the next by a curved plate.

The mill rolls are supported in massive castings. The heavy stresses the rolls and frames must withstand due to crushing pressures requires massive machines. Each three-roll mill, with rolls from 5 to 7 feet in length, may run from a minimum of 45 tons to as much as 100 tons. A crusher, preceding the tandem rolls, may run from 30 to 40 tons. Thus, crusher and three-mill tandem may run from 165 tons to 340 tons.

The hydraulic pressure applied to the rolls varies with the length of the rolls, the strength of the mill and the quantity of the cane to be ground. Pressure is also varied with the position of the mill in the series or tandem. It is not uncommon for 500 tons and upward to be applied. Pressures may be somewhat less on the crusher, varying with practice as to loading, but hydraulic pressures of 150 to 250 tons are common.

In modern practice, cane elevators, knives, crushers, and mills are driven by separate electric motors. Due to the pressures involved in crushing a full load of cane, such motors must be of relatively large size. Power for motors usually is provided by steam turbogenerators operating from boilers. In turn, exhaust steam from the turbines is used in the evaporators.

Juice from the milled cane is piped from the mills to tanks where it is limed to precipitate impurities and to clarify the juice. The juice is then pumped to succeeding processes—settling, evaporation, and to final crystalization. These processes vary to some extent, but in principle they provide for clarifying the juice, and the application of heat in closed or vacuum retorts to remove moisture until the remaining concentration is sufficiently heavy with crystals to permit separation of crystals from liquid by centrifuging. (See appendix I for details of a representative mill.)

The byproduct of milling cane is bagasse, the woody fiber of the cane left after extracting the juice. It is valuable as fuel and in modern mills, supplies all that is necessary, except for starting boilers, and leaves an excess for manufacture into fiberboard, or similar byproducts. In some areas, some of the bagasse is compressed into small bales to be used as fuel for the locomotives on the mill's narrow-gage lines. An analysis of Hawaiian bagasse shows:

TABLE VII.—*Bagasse as fuel*

Percent moisture in the bagasse:	*Fuel value per pound of bagasse, B. t. u.*
42	3,129
43	3,057
44	2,982
45	2,909
46	2,835
47	2,762
48	2,687
49	2,614
50	2,540
51	2,468

Evaporation of moisture from the cane juice results in a concentrated syrup in which the sugar has been crystallized or the material has been concentrated to a point where it will crystallize. This is known as massecuite. When a massecuite is spun in a centrifugal machine the sugar crystals are separated from the mother liquor. This liquid is then termed "molasses." The "final" or true molasses is the liquid residue from which no more sugar can be removed, either because of factory equipment or for commercial reasons. Molasses is a byproduct in the manufacture of raw sugar. It still contains sugars. Molasses is frequently used as a raw material for manufacturing alcohol.

There are at least five sugar mills on the islands—one on Saipan, two on Tinian, and two on Rota. One of the mills on Rota was built in 1939. The others are somewhat older but each is comparatively modern. In 1935, the foreman of a mill in Saipan was trained in Cuba. It is known, also, that the Japanese observed closely mill operations in Hawaii and probably adapted many of their techniques and operating procedures. The mill on Saipan in 1935 used bagasse for fuel. Probably all do. Lack of other fuels emphasizes the efficacy of doing so. (Individual mills will be taken up under sections relating to specific islands.)

The type and make of crushing, milling, and refining machinery probably is of Japanese manufacture. Development of the sugar industry in Formosa, as well as in Japan proper, created a demand for

milling machinery which the Japanese probably have supplied.

ALCOHOL

The fact that plants for manufacturing intoxicating liquors are reported on Ponape, Truk, Palau, and Yap—even though no sugar is reported—is likely evidence these islands must also have some facilities for crushing and milling cane to supply cane juice to stills. (Individual mills will be taken up under sections relating to specific islands.)

Alcohol plants are set-up as part of the sugar factories. Some, if not most, produce 95 percent, 190° alcohol. The number of concerns which have been granted permission to manufacture intoxicating liquors is much greater than the number of sugar mills. In 1937, according to the official Japanese report to the League of Nations, there were 21 concerns for manufacturing intoxicating liquors, located as follows: Saipan 13; Palau 2; Truk 2; Ponape 3; and Yap 1. Undoubtedly some produce alcohol while others may merely rectify or mix spirits for beverage purposes. It is probable, however, that most plants produce alcohol from molasses or cane juice as the primary raw material. Production is shown in the following table:

TABLE VIII.—*Mandated islands: Production of molasses, alcohol, and alcoholic liquors, 1932-38*

Year	Molasses	Alcohol	Alcoholic liquors
	Metric tons	*1,000 liters*	*1,000 liters*
1932	13,097	1,500	516
1933	13,102	1,672	717
1934	10,557	1,762	641
1935	9,273	1,826	855
1936	13,224	2,551	1,031
1937	19,053	2,668	1,222
1938	15,503	3,453	1,433

Alcohol production shown in the above table is in terms of 95 percent alcohol. Most of the alcohol probably is exported to Japan proper or made available for fleet use. It is improbable that any molasses is exported but rather that it is used at the point of production for distillation.

SUBSIDIES

The sugar industry in the Saipan district has operated with a subsidy. Subsidies have been granted for various phases of development, including planting or seedlings, land reclamation, nursery stock, and the promotion of green cover or manure crops. Shipping also received a subsidy, although it seems to have been discontinued in 1936.

Subsidies also were given for other agricultural development as well as to various businesses. Apparently subsidies were granted as a part of the Japanese policy of colonial exploitation in the mandates.

Table IX shows the amount of subsidies granted the sugar industry in the mandates in specified years; also the amounts and rates of subsidy for specified phases of the industry.

TABLE IX.—*Sugar industry subsidies*

	1933	1934	1935	1936	1937
Sugar subsidies, total	¥471,044	¥481,856	¥485,605	¥53,915	¥17,097
Seedlings	56,405	78,567	77,953	31,372	10,258
Land reclamation	28,547	41,035	22,907	----	----
Nursery	21,511	26,676	28,142	21,737	5,512
Green manure crops	86	75	143	806	1,327
Shipping	372,494	335,503	356,460	----	----
Sugar acreage subsidized:	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Seedlings	6,328.3	8,832.3	10,679.6	7,786.1	(?)
Land reclamation	3,177.7	4,569.2	3,116.4	----	----
Nursery	1,220.1	1,433.3	1,506.8	1,122.1	(?)
Green manure crops	26.9	24.5	46.5	262.2	(?)
Per acre rate of subsidy:					
Seedlings	¥8.94	¥8.90	¥7.30	¥6.92	(?)
Land reclamation	8.98	8.98	7.35	----	----
Nursery	17.63	18.61	18.68	19.37	(?)
Green manure crops	3.20	3.06	3.07	3.07	(?)

The drastic cut in total subsidy payments in 1936 is accounted for mostly by elimination of shipping payments. Land-reclamation payments were discontinued the same year. Payments for seedlings and nursery also were reduced in 1936 with even greater reductions in 1937. Records for following years are not available. It is somewhat significant that the total payments for green manure crops show a rising trend during the years specified. The rate per acre was approximately the same for each year but the acreage qualifying for green manure crop payments increased steadily. Due to the thin layer of soil and its general need for nitrogen, the operators probably found their yield declining unless they instituted soil practices which returned nitrogen-bearing organic material to the soils.

Shipping subsidies on sugar from the mandates were at the rate of ¥7.87 per short ton in 1933, ¥6.24 in 1934, and ¥5.71 in 1935.

A comparison of sugar subsidies and the value of sugar exports is shown in table X.

The sugar company also is exempt from Japanese business and income taxes, although port clearance

taxes are paid, but these are in lieu of consumption taxes paid in Japan.

Subsidies are paid also to other agricultural developments. They are granted for much the same types of considerations as apply to sugar. The coconut industry, coffee growing, livestock production, vegetable growing, fishing, and various commercial enterprises such as hotels, warehouses, printing, bathhouses, and loan companies, have benefited from the subsidy program.

TABLE X.—*Sugar subsidies and value of sugar exports*

[1,000 yen]

	Total subsidies	Sugar exports		Total subsidies	Sugar exports
1933	471	12,900	1936	54	13,000
1934	482	12,400	1937	17	19,600
1935	486	18,100			

Other agricultural crops produced in the Saipan district include cassava or manioc from which tapioca is produced, coffee, pineapples, and vegetables. The Japanese report the following vegetables under cultivation: leafy vegetables, sweetpotato, taro, cucumber, watermelon, onions, tomatoes, carrot, burdock, radishes, and cabbage. Other vegetables have been grown successfully on Guam, hence it is probable that many of them can also be produced on Saipan, Tinian, and Rota. The experiment station at Ponape has adapted other vegetables for that island also, including cucumber, eggplant, tomato, radish, okra, lettuce, carrot, onion, squash, pumpkin, melons, watermelons, chinese cabbage, peas, beans, spinach, potatoes, and sweetpotatoes. These developments have received much attention from the South Seas government in the form of trained specialists and financial aid. The importance of producing food for consumption by the colonists, thereby reducing imports and shipping requirements, emphasizes the desirability of such policy. Also, it is further emphasized by the wartime policy announced January 1944 (cf. p. 3) requiring increased production of subsistence crops in the mandates.

III. THE MARIANAS

The most important commercial sugar-producing areas in the Japanese mandated islands are located in the lower Marianas, centering primarily in Saipan, Tinian, and Rota. Some sugarcane is reported on Aguijan Island but there is no supporting evidence of milling activities. Sugarcane is also reported on Agrihan.

SAIPAN

PLANTATIONS

Three sugarcane plantations were reported on Saipan, each operating under Nanyo Kohatsu Kaisha. Intelligence reports indicate that plantation No. 1 occupies most of the southern portion of Saipan and extends from Askanno to Mount Nafutan and almost to Nafutan Point. This appears to be the largest plantation on the island, covering 8 to 12 square miles, or 5,000 to 7,000 acres. Narrow-gage railways interlace the plantation. Roadways run through the fields and in turn connect with the narrow gage.

Plantation No. 2 is on a high, fairly level plateau in the east-central peninsula. Cane fields extend up the eastern slopes of Mount Tapotchau for a short distance. It appears to be about one-half to two-thirds as large as plantation No. 1. The narrow gage runs to the cane fields and also connects with plantation No. 1 and the sugar mill at Charan-Kanoa.

Plantation No. 3 occupies all the flatland along the coast north of Makunsha around to Kalapera. The total length is about 12 miles and the average width, 800 to 1,000 yards. The plantation assumes an inverted U-shape in the center of which are 900-foot elevations including Mount Marpi and Mount Petosukara which are covered with forests. It too connects by narrow-gage railway, running through cane fields along the flat coastal plain, with the town of Garapan and the mill at Charan-Kanoa.

RAILROADS

Fifty-three miles of railroad, operated by Nanyo Kohatsu Kaisha, were reported in 1936. Some reports state that the railroad encircles the island, although according to a 1942 map, it encircles about three-quarters of the island, connecting the plantations with Garapan, Tanapag, and the mill. It may be a 30-inch gage, although some reports show it as 26-inch. In 1931, the railroad had 3 rails in Garapan, the third being about a foot outside of the other. A line of this sort was said to extend as far south as Charan-Kanoa and as far north as the northern tip of Saipan. In 1931, the rolling stock consisted of 11 engines and 30 cars. Six of the engines were of German make, a hybrid wood-burning type which could hardly haul 6 empty cars. Four of the engines were in use at all times; the other 7 were in reserve or not in use. It appears that some of these engines have been replaced with better locomotives. The locomotives used in 1936 were from 10 to 20 tons in weight and burned coal. Small and large (using the third rail) flatcars and boxcars were seen in use in both 1931 and 1936, but only narrow-gage locomotives were noted.

HIGHWAYS

The total length of roads in 1936, with a width of over 6 feet, was 45 miles of which about 2 miles were 21 feet wide. A plan for road extensions announced in 1938 provided for 3.3 miles, about half of which was new; the remainder was expansion or widening to 14 feet or slightly more. Condition of the roads ranges from fair to poor. Local limestone ("cassajo") is used for surfacing. Surfaced roads connect the towns of Tanapag, Garpan, and Charan-Kanoa. In turn, these connect with other dirt roads and with trails through the plantations.

As of 31 December 1936, the following vehicles were reported in the Saipan district (Saipan, Tinian, and Rota):

Automobiles:	
Passenger	72
Freight	85
Single seat	6
Motorcycles:	
Side car attached	7
Trailer attached	10
Trucks	13
Animal-drawn carts	3,503
Bicycles	9,265
Jinrikishas	6

Carts are used extensively for hauling cane from fields to rail siding. Distribution of the carts among Saipan, Tinian, and Rota is not given in the report.

SUGAR MILLS

A sugar mill is located 4½ miles south of Garapan on the west coast at Charan-Kanoa. It has a capacity of 1,200 tons of sugarcane daily. This mill probably is relatively modern even though the sugar industry in the Mandates was first begun on Saipan. (cf. appendix I for a description of a representative American mill of 1,200 tons of cane per day capacity.) The buildings are three to four stories in height. Narrow-gage rails run to and into the mill to unload cane at the crushers.

Another mill of the same capacity is reported at Akokoru. However, such a location cannot be found. Also, the 1938 report of the Saipan branch administration states that the milling capacity on Saipan is 1,200 tons per day. Thus reports regarding the second mill may be in error.

MOLASSES

The mill also makes syrup or molasses as part of the process of manufacturing raw sugar. The average output is about 45 to 50 gallons of molasses for each ton of sugar produced. Total output for the islands, in 1936, was 13,224 metric tons or about 2½ million gallons of molasses, of which 41 percent or about 1 million gallons was produced on Saipan. Molasses is pumped as it is made into storage tanks resembling silos where it is held for later use. Most of the molasses is probably distilled into alcohol on the island. Molasses is difficult to handle in barrels because it is thick and heavy. Usually it is shipped by tanker; sometimes by barge. Probably none is shipped to Japan from the islands. Distilleries are operated in conjunction with the sugar mill.

ALCOHOL

Alcohol is one of the important byproducts of sugar manufacture. About 340,000 gallons were made on Saipan in 1936; in addition, 34,400 gallons of whisky and 172,500 gallons of other spirituous drinks were made the same year. Thirteen firms on Saipan were licensed to make intoxicating beverages in that year. The basic spirits must have been obtained from the distillery. Some of the licenses may have been for rectifiers.

GRINDING SEASON

The grinding season on Saipan probably extends from January through May, although it may start some years in December or run through part of June. During the rainy season—July through October—it would be difficult, if not impossible, to get cane out of the fields. It may also be too wet to plant cane during the rainy period. Plantation foremen arrange their planting so that the cane will be ripe, that is, contain maximum sugar content, during the harvesting season.

FUEL AND POWER

The sugar mill on Saipan uses bagasse for fuel. Some oil or coal may be necessary to start the boilers at the beginning of the season. Thereafter bagasse should furnish more than enough fuel for mill operation. Bagasse may also be used in the distilleries.

At least five electric generators were reported in 1932 on Saipan. Two were steam turbogenerators connected to the sugar mill, generating about 300 kilowatts. Power for motors driving milling machinery was taken from this source. They also provided lights for Charan-Kanoa. The other three generators operated on diesel oil or gasoline and generated less than 50 kilowatts.

WAREHOUSES

Eight warehouses, owned by Nanyo Boeki Kaisha (an operating affiliate or subsidiary of Nanyo Kohatsu Kabushiki Kaisha) were reported in 1936 near the NBK pier in Garapan. Raw sugar awaiting shipment is stored there. Only small buildings, other than the sugar mill, are reported at Charan-Kanoa. Hence raw sugar must be shipped from the mill as it is made to the warehouse to await shipment. Unless dock facilities have improved in recent years, sugar is lightered in small boats and sampans from warehouse docks to ships.

LABOR

Japanese colonists comprise the labor force for the sugar industry. Some few natives grow cane but their number is small, totaling only 41 households or 130 persons in 1937, with plantings of 232 acres. All labor, both skilled and unskilled, in the mills probably is Japanese. Technical skills are required for many operations. Machinists, engineers, chemists, etc., are necessary to operate the mills. Many probably have been trained in Formosa; some have had experience in Hawaii. In 1936, the foreman of the Saipan mill was trained in Cuba.

Work on the plantations probably is mostly by men although women and children may help some with planting and cultivation. It is unlikely that they are used for harvesting because it is somewhat dangerous, as well as heavy work.

OTHER CROPS

Sugar is the most important commercial crop in the Saipan district. However, other crops are grown, the acreage of which is shown for 1936:

TABLE XI.—*Crop acreage*

Sugar	9,188
Cassava (tapioca)	2,053
Papayas	409
Coffee	7
Vegetables	808
Cotton	205
Sweetpotatoes	604
Bananas	30
Others	49
Total	13,353

Another important crop is coconuts from which copra is made. The coconut palm grows on all the islands and atolls of the Mandates. Coconuts are not only an important food for the natives—sometimes their chief food—but also copra is the chief article of commerce which the natives trade for consumer goods. Although copra does not assume as great a relative importance in the total trade of the Saipan district as it does in the Ponape or the Truk districts, it does rank high in the commerce of the natives. Coconut acreage and copra production in the Saipan district was as follows:

TABLE XII.—*Coconut acreage and copra production Saipan district, 1936–37*

Government-owned plantations	acres	4,862
Privately owned plantations	do	2,322
Total, 1936	do	7,184
Copra, 1936	tons	830
Total, 1937	acres	7,744
Copra, 1937	tons	750

Coconuts are grown chiefly in the northern part of the Saipan district. In the latter part of 1935, insects attacked the coconut trees of Saipan. All infected trees were cut down. Since then efforts have been made to exterminate the pest—with undisclosed results. Increased plantings of coconuts have been favored by the government, as also have improvements in drying facilities. Subsidies were granted in 1933, 1934, and 1935 for such purposes. Some coconut oil is produced in the district. A subsidy was granted in 1933 to assist such manufacture.

Copra is considerably more important to the natives as a commercial crop than is sugar.

TINIAN

Tinian is about 2¾ miles southwest of Saipan and 4¾ miles northeast of Aguijan Island. It is about 85 percent as large as Saipan with total area estimated as approximately 24,000 acres, of which 82 percent is estimated as arable and 75 percent under cultivation. Tinian is separated from Saipan by a narrow channel. Sugar producing is the most important industry on the island.

PLANTATIONS

Sugar cane (cf. table I) on Tinian was estimated as 14,800 acres in 1938, the largest plantings on any of the islands, or about 50 percent more than Saipan and over twice Rota's acreage. Plantations are distributed over most of the island, particularly on the the western side which slopes gradually toward the shore. A ridge runs close to the eastern shore connecting Maga and Lasso hills in the north with hills in the southern parts of the island near Marpo Point and Lalo Point. Spottily distributed brush covers the ridge and most of the land not planted to cane. Apparently cane is grown not only on the western slope but also on the northern point between the Maga hills and Ushi Point. Cane also is grown between Tinian town (Sunharon) and the hills to the southwest near Marpo Point and Lalo Point.

Sugarcane has been planted on Tinian to the exclusion of most other crops. Other food supplies are limited. Vegetables are grown by colonists for their own use and are plentiful during the wet season, from June through November.

RAILROADS

There were 49 miles of railroad on Tinian Island in 1936, built and used primarily to serve the sugar fields. Starting from Tinian town a line practically encircles the island. Its gage has been reported variously at 26 and 30 inches, but the latter is probably correct. In 1929 it had six 14-ton locomotives, half of which used coal as fuel and half gasoline, and about 200 cars.

HIGHWAYS

There are few roads and trails, and they are generally worse than those on Saipan Island. A program of road improvement outlined in 1937 provided for approximately 20 miles of gravel ("cassajo") roads, mostly connecting Tinian town with outside points.

SUGAR MILLS

Two sugar mills are located close together in Tinian Town with a reported capacity in 1936 of 2,200 tons

of cane per day. The mills are the biggest buildings in the town, each being four stories high. They are of relatively modern construction, probably having been built within the past 15 years. Narrow-gage railways connect the mills with plantations. Three molasses storage tanks are located between the mills and the harbor. A pier which may be used for loading sugar adjoins the mills. Raw sugars are made and shipped to Japan for final refining. Over 50 percent of the sugar manufactured in the Saipan district in 1936 came from Tinian.

Small sheds surround the sugar mill, presumably warehouses for raw sugar.

MOLASSES

Molasses is manufactured as a byproduct of sugar. In 1936, production totaled about 1.4 million gallons. All molasses probably was used for distilling alcohol.

ALCOHOL

Alcohol production in 1936 was about 430,000 gallons of 190° spirits. No whisky or other liquors were reported. Distilleries are located close to the mills.

GRINDING SEASON

The grinding season is the same as in Saipan, as conditions are similar.

FUEL AND POWER

The sugar mills use bagasse for fuel, as in Saipan. Each mill has a steam turbogenerator supplying power to operate crushers and mills.

WAREHOUSES

Warehouses surround the mills for temporary storage of raw sugar. Sheds for sugar storage are located also on the pier at Tinian Town.

LABOR

The labor force in the Tinian sugar industry is almost completely Japanese. There were only 26 natives compared with 31 Koreans and 15,280 Japanese on Tinian in 1936. Japanese colonists operate the plantations, as well as provide the direct labor, both technical and unskilled, for the mills.

OTHER CROPS

Sugarcane is the most important crop on Tinian. Only 66 acres of other crops are shown in 1936—made up as follows: Sweetpotatoes, 29 acres; bananas, 10 acres; others, 27 acres;—compared with 14,211 acres of cane. It seems probable that garden plots for workers comprise a larger acreage than the above figures indicate, but they are not recorded as such.

ROTA

Rota, somewhat smaller than either Saipan or Tinian, lies about 32 miles northeast of Guam and about 45 miles southwest of Tinian. Rota's total area is approximately 20,000 acres compared with 24,000 and 29,000 for Tinian and Saipan, respectively. A Saipan district report of the South Seas bureau estimates that about half the land is arable, most of which is cultivated. Sugarcane is the most important crop in the island, as also sugar refining is the chief industry.

PLANTATIONS

Sugarcane is grown in the area northeast of Rota on the low plateau running along the north shore and the north central portion of the island. Cane acreage was estimated as 6,187 acres in 1937, or about 20 percent of total acreage in the three islands. Cane yields on Rota in that year were less than on either of the other two islands, as also was the percentage of sugar in the cane. Hence, sugar production was less than 20 percent of total tonnage. Cane yields in 1937 were 11.2 tons per acre compared with 28.6 tons and 25.8 tons of cane in Tinian and Saipan, respectively. The percentage of sugar from sugarcane for the same year was: Rota, 8.64; Tinian, 10.91; Saipan, 12.07.

RAILROADS

There are 22 miles of narrow-gage railroad on Rota, built by and for the sugar companies. Rails run from the sugar mill and Rota village along the western and northern shores of the island, making a loop at the northeastern end. Rails connect the plantations with the town and mill.

HIGHWAYS

There are one or two good roads on Rota suitable for motor vehicles. One connects the sugar mill and the town. About 1 mile of 30-foot road was reported in 1936, also 19 miles of 7-foot road. A road-improvement program projected at that time provided for an additional 5 miles of 18-foot road and 5½ miles of 10-foot road. Dirt roads probably connect cane fields with rail sidings.

SUGAR MILLS

Cane is milled in the island. A mill is located just south of Rota village on the west coast. Total milling capacity on Rota was reported by the Saipan branch of the South Seas government as 1,200 tons

of cane per day in 1936. A new factory supposedly was built in 1939, 3 to 5 miles southeast of Rota village on Sosonjaya Bay which, if correct, should have increased capacity unless an older mill was abandoned. However, the plant located in this area does not have the appearance of a sugar mill. It is probably used for some other purpose.

The mill on the west coast is reported as a "compact" mill, four stories high. Mills on Rota, as on the other islands, produce raw sugar, also byproducts such as molasses.

MOLASSES

Molasses is produced in the sugar-manufacturing process. Data is not available concerning the quantity, but at least 400,000 to 500,000 gallons should be produced, based on average outputs.

ALCOHOL

No alcohol production was reported on Rota in 1936, although later reports state that alcohol is produced. It is likely that molasses is converted to alcohol on the island. Rota's distance from Tinian and Saipan, as well as the difficulties of barging molasses between islands, emphasize the probability of alcohol production.

GRINDING SEASON

The grinding season on Rota is the same as for Saipan and Tinian; that is, during the dry season running generally from January through May.

FUEL AND POWER

Bagasse is the main source of fuel for sugar milling on Rota. Steam turbogenerators are connected to mills which provide electricity for motors used to drive milling machinery. The capacity of the generators is not reported, but they probably are about 300 kilowatts.

WAREHOUSES

Warehouses surround the sugar mills. Raw sugar probably is barged from Rota to Saipan for loading aboard ships for Japan.

LABOR

Labor in Rota's sugar industry, plantations as well as mills, is almost wholly Japanese. The total population was reported as approximately 6,000 in 1936, of which about 85 percent were Japanese. The Japanese population probably has increased since that time as agricultural and military activity increased.

OTHER CROPS

Although sugar is the chief commodity, other crops are grown. The extent of their cultivation is shown in table XIII:

TABLE XIII.—*Acreage of sugar and other crops, Rota, 1936*

	Acres
Sugar	6,188
Cassava (tapioca)	7
Papayas	735
Sweet potatoes	29
Bananas	10
Vegetables	653
Others	27

Coconuts are indigenous to the island. The extent to which they are grown commercially is not known. The natives probably produce some, although production must be relatively small (cf. coconuts, Saipan).

AGUIJAN

Aguijan is a small island lying about 5 miles off the southwest coast of Tinian and about 42 miles north-northeast of Rota.

Some sugarcane has been reported on the island but no data is available. Any cane grown on Aguijan probably is an extension of activities on Tinian and is milled in Tinian. It should be considered with Tinian.

AGRIHAN

Sugarcane also is reported on Agrihan, which is a small island in the northern end of the Marianas chain. No data is available. Quantities, if any, probably are small.

IV. THE CAROLINES

PONAPE

Reports on sugarcane production in Ponape are conflicting. Some cane production has been tried. Only 3 acres of cane were reported in 1937. Two liquor-manufacturing plants were reported on Ponape that year. Further reports indicate that the South Seas Development Co. was clearing land in 1936 and 1937 preparatory to planting crops, including cane.

Ponape's climate is the wettest of any islands in the Mandates, averaging about 200 inches of rain annually, rain occurring over 300 days each year. Cane should grow well, although the island lacks sufficient dry season to harvest and mill cane successfully. Also the high humidity would increase the difficulty of handling raw sugar. It is likely that if cane acreage has increased appreciably, the cane juice goes directly to distilleries for conversion to alcohol.

OTHER CROPS

Breadfruit, cassava (tapioca), and copra are the most important crops in Ponape. Crop acreage in 1937, in the Ponape District of the South Seas government, is shown in table XIV:

TABLE XIV.—*Ponape district, acreage and production of specified crops*

	Acres	Production (short tons)
Coconuts:		
Government owned	8,133	----
Privately owned	10,664	----
Total	18,797	3,578 [1]
Breadfruit	1,038	4,733
Cassava (tapioca)	1,285	11,154
Sweetpotatoes	325	1,147
Bananas	210	583
Rice	64	40
Pineapples	35	10
Papayas	45	103
Cotton	32	13
Coffee	7	.2
Sugarcane	3	50
Vegetables	325	710
Others	49	(?)

[1] Copra, 1938.

Extensive efforts have been made by the South Seas government to develop agriculture in the Ponape district. An experiment station has been carried on by the Japanese in continuance of some work begun by the Germans. Under the leadership of Hoshino, known as the Burbank of Japan, the experiment farms have devoted intensive effort to adapting plants which would fit into the Japanese economy and the economy of the islands.

Development of the Ponape experimental farms appears to be relatively extensive. They also have carried on agricultural demonstration work and practical farming among the natives. Some improvement in native agriculture and the standard of living among natives has been noted.

Ponape's agricultural station, with its corollary effects on colonist and native agriculture, appears to be a tangible and valuable contribution to the general subsistence and commercial economy of the islands. Adaptions of plants to Ponape's soil and climate represent long, time-consuming experimental work and expense. The current status of such work is not known. Special effort might be made to have such work inspected and assayed by trained scientists—horticulturists, agronomists, botanists, and entomologists—to determine its current and prospective worth to the economy of the natives and occupying forces.

KUSAIE

Attempts have been made by the Japanese to grow sugarcane on Kusaie, but with no success. Other crops such as coconuts, cassava, and particularly pineapples, have been grown satisfactorily. In recent years, the needs of the military forces for fresh vegetables have led the South Seas Development Co. to undertake truck gardening on an extensive scale.

TRUK

No sugarcane is grown for commercial purposes on Truk islands. Other crops are grown as follows:

TABLE XV.—*Truk district, acreage and production of crops, 1937*

	Acres	Production short tons)
Coconuts	10,468	(?)
Breadfruit	7,573	15,298
Sweetpotatoes	7	28
Bananas	17	84
Pineapples	17	37
Vegetables	631	1,072

An experimental farm is reported on Truk.

PALAU

Attempts have been made to grow sugarcane for commerical purposes on Palau but the results are uncertain. Cane acreage, if any, probably is very small.

An extensive experimental farm is located on Koror Island which is important to the agriculture economy of the Palau group.

V. IMPORTANCE OF AGRICULTURAL EXPERIMENT STATIONS IN THE JAPANESE MANDATES

The Japanese have directed a great deal of governmental interest, scientific time and effort, to the development of experimental farms or agricultural experiment stations in the mandated islands. Experimental farms or stations are located on each of the important islands. This policy accords somewhat with that followed by the United States Government in promoting agriculture in its outlying possessions by developing and supporting agricultural experiment stations for agricultural research and, in conjunction therewith, demonstration and extension work. The United States Government has such stations in Puerto Rico and Hawaii. It also cooperates with the State governments in operating experiment stations in each State. The Federal Government operated an experiment station in Guam from 1910 to 1932. The results of work on Guam should be valuable in considerations for the Mandates, particularly the lower Marianas.

Experiment stations and farms offered a sound application of scientific knowledge and techniques to the problem of practical development of agricultural crops in the islands. Better strains and varieties of indigenous plants, such as coconuts, breadfruit, yams, etc., were developed. Also, plants from other areas were adapted to climatic and soil conditions in the islands. These have contributed to the economy of the empire and of the islands, particularly in providing better opportunities for colonial exploitation. The benefits have flowed mostly to the Japanese colonists who have been either more amenable or tractable in following the agricultural policies of the Japanese than have the natives. The natives benefited to the extent that they have been given new varieties or species for their own subsistence.

The experimental farms are a real asset to the islands. Results of their work should be of great value in outlining the course to be followed in agriculture in the islands. It is important to the natives, to occupying forces, and to the United States Government that the best use possible be made of the developments coming out of the experiment farms.

The largest and most important experiment station is on Ponape. This project was first started by the Germans. The Japanese continued, expanded, and intensified the work. Hoshino—known as the Burbank of Japan—was in charge of the station for years. He is supposed to have developed approximately 250 plant adaptions which contribute to the food economy of the islands.

Stations also are located on Truk, Saipan, Palau (Koror) and Yap. Pictures of the Palau station show it to be a large project. An experiment station probably is located on Kusaie also. Each station is extremely important to the continuing agriculture of each island. The effort, time, and expense of developing plants or crops for each island comprises an asset that can be easily liquidated but not easily regained except by pursuing similar procedures at similar cost.

VI. COURSES OF ACTION

MARIANAS: SAIPAN, TINIAN, ROTA

Outlook for the sugar industry.—Total sugar production in the Marianas is a relatively small percentage—4 to 6 percent—of the supply for the Japanese Empire and less than 1 percent of supplies normally available to the United States (table III, p. 5). Prospects of Marianas sugar competing successfully in the United States or world markets during peacetime, without special subsidies or preferential colonial protection, do not appear bright. Furthermore, Taiwan is capable of producing all the sugar necessary for the Japanese Empire, and at a lower cost than the Marianas.

The sugar industry, which competes under modern conditions in the world market, is of necessity a large-scale operation requiring sizable capital and large labor forces. If soil and climate are particularly favorable, mechanical operations may reduce labor requirements considerably in soil preparation, cultivation and harvesting. Cane yields in the Marianas indicate that soil and climate are favorable, but not unusually so (table II, p. 5). The availability of additional land suitable for cane production in other areas and more stable labor supplies in other areas places the Marianas in a difficult competitive situation in the world sugar market.

Importance of the sugar industry to the Marianas.—Sugar production is the most important industry in the Marianas while they remain under Japanese occupation. It is important, however, chiefly to Japanese colonists. Very few natives participate or benefit. Some few grow cane (p. 6) but they have not taken it up to any appreciable degree. The industry's importance to the islands under American occupation depends upon the disposition which is made of Japanese colonists.

Labor.—Labor in the sugar industry, both mill and plantation labor, is preponderantly Japanese. If all remaining Japanese are interned, pending final disposition, no labor will be available for cultivating or harvesting, except for the few native farmers; no labor for mill operation will be outside military custody. Some colonists, if approved under security regulations, may be released under proper surveillance for work in the cane fields, if their labor is not needed more in other labor details. If such labor, such as women, youngsters, and older men, becomes available, it may be more profitable to the occupying forces to direct them to the production of vegetables and other supplies for provisions to be used by themselves and occupying forces, than to sugar production.

The South Seas Development Corporation contracted with independent farmers, both Japanese and native, to buy all cane produced by them at prices announced by the branch bureau. All native farmers might be identified, their holdings and cane acreage ascertained, and yield estimated.

Consideration might be given to paying them for their cane, whether it is harvested or not. Such policy depends upon the extent to which their continuing good will is important, currently and in the future, to United States policies. If such payments are made to native farmers, their fields might be identified specifically. Records might be made and held by military government officials so that additional payments would not be made the following year for the same cane. Incentives for converting from cane to edible crops might well be coupled with payments for current cane production.

Sugar mills.—Sugar mills will be targets for attacking forces. Buildings will be destroyed to a great extent. So will such of the milling machinery. However, milling machinery is of heavy construction, and unless it suffers direct hit, some may be salvaged. A sugar mill engineer, operator, or foreman from Hawaii, if available, may be requested to inspect captured mills to determine if enough machinery can be salvaged from all mills to reestablish a small operation sufficient to grind cane from native farmers and to supply raw sugar to fill native and Japanese internes' requirements. If sufficient machinery is salvageable for reestablishing a small mill, consideration must also be directed to supplies of technically trained labor among colonists for successful mill operation.

Sugar requirements among the native population will be a continuing demand. Should it be impossible or undesirable to reestablish a small modern type mill from salvageable materials and machinery, more primitive mills and methods may meet native needs. Small mills, readily procured from American farm

machinery manufacturers, driven by gas engines which natives may operate, could be used for crushing cane. Wind-driven mills of the Dutch type are still used in the Barbados and other Caribbean areas. These consist of a stone structure somewhat resembling a lighthouse, upon which large wind vanes are mounted. The power shaft connects with rollers or crushers, of a three-roll type, mounted either horizontally or vertically, through which the cane is passed once or more, to extract the juice. Open evaporating pens heated by direct fire may be set up on brick or stone kiln foundations. Bagasse from the crushers, if dried in the sun, can be used for fuel. Sirups of high sugar content may be made in this way, and with elementary training raw crystal sugar can be precipitated. While such methods are primitive, they are used in many areas where sirups and raw sugars satisfy local demands. A minimum of technical and mechanical skill is required for such operation.

Raw sugar.—Should warehouses with raw sugar be captured, estimates of native requirements for 6 months to a year may be made and such amounts stored in dry, protected storage. If more than a year's supply is on hand, the surplus may be shipped to Hawaii or to the United States for refining. Sugar supplies available to the United States and demand are such that all raw sugar may be used to advantage in the war effort. Until the Philippines are recaptured, sugar will remain a relatively critical food item in the United States.

Possibilities of a native sugar industry.—Sugarcane has been grown in the Marianas for many years. The natives, prior to Japanese occupancy, grew some cane for chewing. It supplied, in raw form, some sweetening which they required. Natives will continue to need some sweetening agents. Such needs must be supplied either by imports or by local production. Local supplies probably will have to be on an island-by-island basis, except for the lower Marianas where, due to short distances, native craft can freight supplies among them. Although the number of natives engaged in cane production is small, these few apparently have developed some understanding of a market economy and they may be willing, perhaps even desirous, of continuing their own limited production. It may be significant to note in passing that the local assembly was petitioned by Guam natives in the late thirties to build a sugar mill there. However, no commercial cane is grown in Guam. If sufficient natives in Saipan, Tinian, and Rota request continuance of a sugar industry, their acreage may be kept under cultivation and small mills may be constructed for supplying natives' needs. Small mills capable of crushing from a few hundred pounds to a ton or two per hour are built by American farm machinery manufacturers. Such mills are powered by a mule or other beast of burden hitched to the end of a sweep, by gasoline engine, or motor. Presumably they could be adapted for windmills, if such should be feasible. Mills of this type consists usually of three rolls approximately 12 inches in diameter and from 9 to 18 inches in length of roll.

Evaporators may consist of open pans over a direct fire. Most of such equipment, except for the mills and the metal evaporating pans, can be constructed of local materials by common labor under supervision.

Effects of a lapse in sugar production.—A lapse in sugarcane harvest or milling should not seriously affect the growing cane. It is not uncommon in many sugar-producing areas to allow cane to carry over for an extra year or two after the first season when it ordinarily should be harvested. The only probable effect on the cane would be continued growth with an increase in size and tonnage and some loss in the percentage of juice to fiber. Cane in the Marianas probably would continue to grow indefinitely. Existing fields of cane might be used by natives in future years as a source of supply. As natives cut cane from existing fields, they might then be converted to other crops, should such a course be desirable.

As cane continues to grow from year to year, it may become virtually a cane jungle. However, unless it becomes a menace for reasons of safety and a harbor for vermin, no action need be taken.

Conversion from sugarcane to other crops.—Should it be determined that neither labor nor processing facilities are available for reestablishing the Marianas sugar industry to its pre-war status, the land which has been cleared, ploughed, and cultivated still remains as a most important factor in potential production.

Demand for vegetables and other edible crops by natives and occupying forces may offer an alternative use for such lands. If natives have a need for and a desire to maintain a source of income from commercial crops, such incentives may expedite conversion from sugarcane to subsistence crops.

Natives may be hired through their headman or chief, to clear the land of cane and to prepare the soil for planting vegetables. Should native labor be insufficient to clear enough land to meet the fresh

produce requirements of occupying forces, track-laying tractors or jeeps may be hitched to plows.

Crops which have been adapted to Guam may be grown by natives for military needs. Also, garden plots of Japanese colonists should provide useful and fruitful evidence of crops which do well. CAUTION.—Leafy and other vegetables should not be eaten without cooking; Japanese colonists probably use night soil as fertilizer. Such vegetables may be contaminated with virulent germs.

Vegetables and other edible crops which can be grown are listed in appendix II.

Experiment stations.—Considerations applicable to the sugar industry need be limited only to the Marianas. Problems in other islands follow outlines similar to those for increasing edible crops in the Marianas. The most important problem in conjunction therewith is determining the plants or crops which will grow successfully and which can be used.

Serious consideration might be given to salvaging possible benefits for current and future agriculture in the islands from experiment farms. To this end a group of experts might inspect and assay the agricultural experiment stations in each island, Ponape, Kusaie, Truk, Saipan, Palau, and Yap. Following the foregoing survey, and a report thereon, provision could be made to continue operation of such plots and plants as are deemed advisable.

Procedures that might be followed in salvaging agricultural experiment stations on Japanese mandated islands: Steps could be taken to insure the salvaging of all physical facilities, including field plots and plant materials, and all records and informational material that might be useful in any future development of these experiment stations in the interest of improving the agriculture of the islands, as follows:

(1) Immediately following occupation of an island on which an experiment station is located a group of experts, including men competent in the pertinent fields of agricultural science and in experiment-station administration, could survey the experiment station, examining all experimental plots, plant materials, records, buildings, laboratories, etc., and determine what experiments and facilities were worthy and susceptible of salvage. Included in the group of experts could be men trained in the following subjects, preferably with experience in a tropical agricultural experiment station: horticulture, agronomy, plant pathology, entomology, agricultural engineering (structures), and experiment-station administration. This group should have available the services of a competent translator. Based on their survey, this group could prepare a report making recommendations for placing the station on a maintenance program, including recommendations on such subjects as:

(*a*) Experimental plots or other experimental work, and plant materials to be maintained, with a schedule of maintenance operation and procedure.

(*b*) Buildings, greenhouses, or other physical facilities to be maintained, with a schedule of maintenance operation and procedure including essential rehabilitation operations.

(*c*) Procedure for safe and orderly preservation of any existing records, publications, and similar materials.

(*d*) Personnel required to place experiment stations on a maintenance basis, including break-down by categories as to skills and levels of competence.

(*e*) Additional equipment required to maintain and operate the station in accordance with the foregoing recommendations.

(2) Following the foregoing survey and report, the necessary administrative, clerical, and operating personnel could be assembled and assigned the task of maintaining the station in accordance with the recommendations of the expert advisory group. The most important individual in the maintenance group would be the man charged with the over-all supervision of the station. Preferably he should have had experience in experiment station operation in the capacity of station superintendent. If such experience had been gained under tropical or subtropical conditions, so much the better. Moreover, it would be advantageous if this man could be on hand at the time the expert group referred to above was making its survey and developing plans for the maintenance of the station. In addition to the station supervisor, one or more men with experience as farm foremen in experiment station work probably would be required to oversee and direct the operational labor.

The necessity of obtaining men for the expert advisory group and the station supervisory positions who have had extensive experience in actual agricultural experiment station work, should be emphasized. Only by so doing can it be assured that sound, discriminating judgment would be exercised in determining upon a rational salvage program, and that this program would be carried out with minimum loss of valuable information and materials.

APPENDIX I.—A TYPICAL AMERICAN MILL

Location.—Louisiana.

Capacity.—1,200 tons of cane per 24 hours.

General information.—This is strictly a central manufacturing concern, buying all cane from surrounding territory. About 50 percent of the cane handled is delivered to the factory by wagons and motor-trucks over the concrete and gravel roads connecting with the plant; and the balance is delivered by rail.

In 1941 the mill ground 65,259 tons of cane, and in 1942, 66,200 tons.

Factory information.—The average number of workers employed in the factory was 150 in 1942 grinding.

Production.—The 1941 production was 10,289,097 pounds of 96° sugar and 460,377 gallons of blackstrap molasses.

The 1942 production was 9,630,980 pounds of washed raw sugar with 371,966 gallons of high-grade molasses and 254,054 gallons of blackstrap.

Sugars made.—Granulated, raws, washed raws; also sirup and high-grade and low-grade molasses.

Carrier feeding.—Carrier slide feed entirely by means of 100-foot steel derrick with 12-foot grab, and 60-foot steel derrick with 7-foot grab.

Carrier is roller-chain equipped and runs up to mill at a 30° angle.

Milling equipment.—Revolving knives, 42 knives, driven by steam turbine, 100 horsepower, through reduction gear and flexible coupling. High knives installed in 1939, set 24 inches from steel carrier and act as leveler, preceding regular set of knives and revolving in opposite direction. Leveling knives rotate at 250 revolutions per minute, regular knives at 500 revolutions per minute.

Two-roll crusher, 30 by 84 inches, journals 14 by 18 inches, driven by 22 by 42 inch Vilter Corliss engine, 32 revolutions per minute.

A 42 by 60 inch cane shredder, 900 revolutions per minute, driven by 16 by 20 inch slide-valve engine. The shredder driven by means of belts and flexible coupling.

A nine-roll milling tandem consisting of three-roll mills, all rolls 34 by 84 inches. Top roll journals 18 by 23 inches and bottom roll journals 17 by 23 inches. The mills driven by engine 32 by 72 inches, 50 revolution per minute.

Grooving.—All mill rolls have ½-inch pitch grooving, 50°.

All mill rolls recently reshelled; and later further strengthened the tandem gearing by installing two new steel intermediate mill gears and pinion.

Mill settings.—Crusher opening equals ⅝ inch.

First mill: Feed opening 7/16 inch tip to tip; discharge opening 5/32 inch tip to bottom.

Second mill: Feed opening 9/32 inch tip to tip; discharge opening 3/32 inch tip to bottom.

Third mill: Feed opening 5/32 inch tip to tip; discharge 0 inch.

Turnplate settings.—

First mill distances from top roll are 1½ inches to 1⅞ inches. Clearance all discharge rolls to heel of turnplate ⅝ inch.

Second mill; respective settings 1 3/16 inches to 1 9/16 inches.

Third mill; respective settings 1½ inches to 1⅜ inches.

Pressures and speeds.—Crusher, 275 tons; roll speed 14 feet per minute.

First mill: 375 tons; roll speed 17.85 feet per minute.

Second mill: 400 tons; roll speed 19.85 feet per minute.

Third mill: 425 tons; roll speed 21.85 feet per minute.

Steam plant.—For bagasse use three water tube boilers at 500 horsepower each.

Forced draft supplied by four 17½-inch and one 15½-inch turbine blowers.

All bagasse furnaces equipped with gas burners.

For gas firing have two h. r. t. boilers, at 250 horsepower each. All gas burners are high pressure. These boilers equipped to burn bagasse by adding a double Dutch oven, induced draft used.

All furnaces are connected to one concrete chimney 6-foot diameter and 150 feet high.

Two duplex steam driven boiler feed pumps each 12 by 8½ by 10 inches center packed plungers.

For storing bagasse.—Pneumatic system. 23-inch wheel fan for blowing out bagasse to two steel storage tanks, one 26-foot diameter and 20 feet high; the other 30-foot diameter and 20 feet high. Bagasse returned by a No. 26 blower.

Clarification.—Four lining tanks 7-foot diameter 11 feet deep; two 750 square feet pressure juice heaters. Intermittent settling system; two 7,000-gallon settlers and four 5,000-gallon each settling tanks.

The mill has three copper brush pans, each 7 feet by 30 inches. In 1939 it installed vacuum-type filter, 8 by 12 feet.

Molasses storage.—It has tanks of capacity sufficient to store 520,000 gallons molasses, and 180,000 gallons magma.

Syrup tanks.—Four, each 14 feet 6 inches long by 8 feet wide by 7 feet 3 inches deep; two, each 20 feet long by 8 feet wide by 6 feet deep.

Molasses tanks.—Five, each 9 feet diameter by 10 feet deep.

Tanks on pan floor—four, each 8 feet diameter by 10 feet deep.

It has a 2,500-gallon capacity "seeder" located on pan floor.

Vacuum system.—For evaporator: Countercurrent condenser; incondensible gases led to auxiliary condenser and washed by sprays of cold water. Vacuum pump: Reciprocating 14 by 22 by 10 inches.

For calandria pan: Parallel current condenser. Vacuum pump: Reciprocating 10 by 18 by 12 inches.

Evaporation.—This station importantly improved in 1936, through installation of a new standard quadruple effect evaporator of 17,000 square feet heating surface. (Replacing former smaller capacity old quadruple.)

Have two vacuum pans, each 10 feet diameter, one a calandria pan, the other coil type.

Have individual vacuum and condenser systems for the big evaporator and for each pan.

Crystallizers.—Ten used for quick working up to second sugars during grinding season; each vessel of size to take a full strike from 10-foot pan.

Centrifugals.—Eight 40- by 24-inch centrifugals equipped with dischargers and sprayers.

Engine driving these machines is a 24- by 48-inch Hamilton Corliss, which also furnishes power for running sugar elevators and conveyors. This installed in 1938 in anticipation of installing modern high-speed contrifugals in future.

Have two-drum granulators for making plantation granulated or refined.

Miscellaneous.—Factory is strictly fireproof, entirely built of brick, concrete, and steel.

The company has a sirup-canning plant, separate from the sugar factory, in a commodious single story brick building, suitably equipped with tanks and canning equipment, with large storage space and convenience to shipping.

APPENDIX II.—VEGETABLES ON GUAM

Vegetables growing in Guam (Bulletin No. 2, Guam Agricultural Experiment Station, Office of Experiment Stations, United States Department of Agriculture).

INTRODUCTION (Excerpts)

Nearly all the common vegetables can be grown in Guam, but those which are introduced from America must be planted in certain seasons for their best development.

Methods adopted for the production of the common vegetable in the States or in the Temperate Zone generally require some modification in the Tropics. These differences are often seemingly insignificant, but upon them depends success or failure in vegetable gardening. Seed which grows well in the temperate regions often fails to germinate in Guam, or the plants fail to produce edible crops. Failure is often caused by loss of vitality of seed, neglect to plant at the proper time, or to select the proper soil, or probably by the adoption of methods of cultivation which are not suitable for Guam.

The two favorable seasons for planting are just before and immediately after the rainy season.

Crop	*Alternative names*	*Prospects*	*Recommended*
Acelga	Swiss Chard	Grows well	Yes.
Amargoso	Paria or ampalya	Native plant	
Arrowroot		Grows well	
Asparagus		Does not do well	No.
Banana		Native, grows well.	Yes.
Beans, green	Practically all varieties.	Very well	Do.
Kentucky wonder bean.		do	Do.
Lima beans		do	Do.
Wax beans—Pencil Pod, black.		Grows well	Do.
Cowpeas		Varying reports	Questionable.
Cerebilla	Bonavist bean	Very well	Yes.
Fijole	Fathom bean, sitac.	Grows well	Not palatable.
Seguidilla	Winged bean	Very well	Yes.
Mungo	Green gram bean	Grows well	Do.
Halflong fijole		do	Do.
Beets		Fair	Do.
Cabbage		do	Do.
Carrots		Grows well	Oxheart, yes.
Calabaza	Bottle gourd	Very well	Yes, highly.
Cassava	Mandioca	do	Yes.
Chayote	Like squash or cucumber.	Fair	
Collards		Grows well	Yes.
Condor	Ash pumpkin	Fair	No.
Corn		Grows well	Yes.
Cucumber		do	Do.
Eggplant		Fair	Do.
Lettuce		Grows well	Caution: if cooked yes.
Mint		do	Yes.
Muskmelon		Very well	Yes, highly.
Mustard		do	Yes.
Okra		Fair	No.
Onions, green		do	Yes.
Onions, dry		Poor	No.
Papaya		Grows well	Yes.
Parsley		do	Do.
Patola	Sponge gourd	Fair	No.
Peas		Poor	Do.
Pechay	Greens	do	Do.
Pepino		Grows well	Yes.
Pepper, green		do	Do.
Pigeon pea		Fair	No.
Plantain		Very well	Do.
Potatoes, Irish		Poor	Questionable.
Pumpkin		Very well	Yes.
Radish		do	Do.
Roselle		do	Do.
Spinach		Poor	No.
Squash		Very well	Yes.
Sweet potatoes		do	Yes, highly.
Taro		do	
Tomato		Risky	May be tried.
Turnip		Poor	No.
Watermelon		Very well	Yes, highly.
Yams		do	Yes.

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