OBSERVATIONS ON METHODS OF GROWING RICE IN JAPAN, KOREA, CHINA, JAVA, AND THE PHILIPPINE ISLANDS

By Jenkin W. Jones

Observations on Methods of Growing Rice in Japan, Korea, China, Java, and the Philippine Islands
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INTRODUCTION

The first commercial rice crop was grown in California in 1912. The high prices paid for rice during the World War resulted in a rapid expansion of the California rice industry, and in 1920 162,000 acres were sown. The acreage in rice decreased during the depression following the World War to less than 100,000 acres, but in 1926 about 155,000 acres were sown. Climatic conditions in California are well suited for the production of the short-grain Japan rices. The medium-grain and long-grain rices, however, do not produce dependable crops. Short-grain rices are, therefore, grown almost exclusively in California.

Due to the fact that the rice crop may be damaged and the cost of harvesting materially increased by early fall rains in California, only midseason and early maturing varieties are now grown commercially. Many varieties and selections have been tested at the Biggs Rice Field Station, Biggs, Calif., during the past 15 years. A number of varieties have been increased for commercial use, and these varieties are now extensively grown in California.

Early maturing varieties, such as Colusa (1600), yield well on virgin land, but early maturing varieties are not so productive as midseason varieties when grown on land that has previously been cropped to rice. There is a demand in California for high yielding, early maturing rice varieties of good quality. Unfortunately, however, high yielding ability, early maturity, and good quality are not usually associated in the same variety.

INTRODUCTION

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Since Japanese rices have been found to be best adapted to California conditions it is natural to turn to Japan for other varieties for trial. In 1925 the United States Department of Agriculture, therefore, decided to send a man to Japan and other oriental countries to make a collection of rice varieties for testing in California and to secure information on the methods employed in rice improvement work and other means of increasing yields and improving the quality of the rice crop.

The writer was selected to make this trip and was authorized to visit Japan, Korea, China, Java, and the Philippine Islands. I sailed from San Francisco on September 1, 1925, for Japan, and after collecting rice varieties in various parts of Japan went to Korea, from Korea to China, from China to Java, and from Java to the Philippine Islands.

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Dr. P. J. S. Cramer, Director of the General Agricultural Experiment Station at Buitenzorg, Java, and Mr. L. Koch, Chief of the Plant Breeding Station for Annual Crops at Buitenzorg gave me a good deal of information on rice growing and improvement in Java for which I am thankful.

To Stanton Youngberg, Director of the Bureau of Agriculture, Mr. M. Cruz, in charge of cereal work for the Department of Agriculture, and Mr. V. Borja, in charge of the Rice Experiment Station at Alabang, I am indebted for information on rice investigation and methods of production in the Philippines. Dr. T. Vibar and Dr. N. B. Mendiola of the College of Agriculture at Los Banos, also gave me a good deal of information regarding rice culture and improvement in the Philippine Islands.

In the pages that follow the methods used in growing rice in the countries visited are given. In preparing this paper material from the Year Book of Japan, the Year Book of China, and the Hand Book of the Netherland East Indies has been used in various places. Statistical reports for the various countries have also been freely used.

JAPAN

The total area of Japan proper is 142,000 square miles, which is slightly more than one-half as large as the State of Texas and about nine-tenths as large as the State of California. In Japan forest covered mountains occupy approximately three-fourths of the total area. Numerous small rapid rivers flow from the mountains into the Pacific Ocean on the east, the Sea of Japan on the west, and into various bays and interior lakes. Arable land is located on the coastal plains, in the valleys between the mountains, and along the rivers. The soil is of volcanic origin, and it is now apparently not exceedingly fertile.

Population

The population of Japan proper is nearly 60,000,000, or about one-half that of the United States. The agricultural population consists of some 5,500,000 farm families of 30,000,000 people. The area under cultivation in 1923 was 15,350,000 acres, less than 17 per cent of the total area, and an average of $2\frac{3}{4}$ acres per farm family. There are about four people in Japan to each acre of cultivated land, while in the United States there are about 3 acres of cultivated land to each person. In Hokkaido, which is much less densely populated, the average size of the farms is about $7\frac{1}{2}$ acres. By comparison in 1925 there were 6,372,000 farms in the United States, 353,000,000 acres in crops, and the average size of the farms was 145 acres.

Japan has about 422 people and the United States about 40 people per square mile. In the three most densely populated countries of Europe, Belgium, England, and Wales, and Holland it is estimated that 74, 73, and 67 per cent, respectively, of each country is habitable, while in Japan only 19 per cent of the total area is estimated to be habitable. Therefore, on the basis of arable land Japan is much more densely populated than these European countries, for there are about 2,321 people per square mile of tilled land. Japan's population is increasing at the rate of over 700,000 per year.

Under ordinary conditions, that is, when unused land is available for tillage, homes, and factory sites, a rapid increase in population is welcome, but in Japan with its limited arable land practically all in use the constantly increasing population is creating a serious economic problem. Hokkaido is not particularly well suited for intensive agriculture, and in spite of encouragement by the Imperial Government the immigration to Hokkaido is relatively small, and only small numbers have immigrated to Chosen (Korea), and Taiwan (Formosa).

Live Stock

In 1923 there was 2,215,398 work animals in Japan for the 5,500,000 farm families, or less than one work animal for each two farm families. While in the United States there are two work animals for each agricultural worker, and in England and Wales, France, Germany, and Italy there is about one work animal for each two agricultural workers. But Japan proper has more work animals per 1,000 acres of crop land than has the United States or England and Wales. This is due, however, to the small area in crops in Japan and not to the large number of draft animals.

The number of dairies and the number of milk cows are decreasing. In 1913 there were 5,644 dairies and 52,478 milk cows, while in 1923 there were 5,063 dairies and 40,972 milk cows. But while the number of cows has decreased during this 10-year period the total milk production has increased nearly 50 per cent. This indicates a marked improvement in the type of dairy cows now in use compared with that of 10 years ago. I saw only one dairy in Japan during travels of over 3,000 miles. Hokkaido is the main dairy product producing prefecture.

Climate 1/

1/ The article entitled "The Climate of Japan and Formosa," by Ellen Mary Sanders, in U.S. Dept. Agr., Weather Bureau Monthly Weather Review 48: 404-408, July, 1920, is the basis of this discussion.

From an agricultural point of view Japan proper may be divided into three climatic zones. The northern zone includes Hokkaido and part of the main island Hondo or Nippon. In this zone the land is frozen during the winter months, and usually only summer crops are grown. The central zone includes practically all of the main island Hondo, except the northern part which lies in the northern zone. In the central zone winter wheat, barley, and leguminous crops are commonly grown during the winter months on paddy and upland. The southern zone, which includes the islands of Shikoku and Kyushu, has a semitropical climate, and as many as three crops in a year may be grown. I was told that in Kochi Prefecture, on the island of Shikoku, it was possible to grow two crops of rice each year.

Certain subdivisions, based upon the rainfall, the frequency of cyclonic storms, and the temperature, are made in the northern and central zones. The northern zone is divided into an extreme northern and a southern division. The extreme northern division, Nemuro type, has a comparatively low rainfall, while the southern division, Hakodate type, is characterized by a heavier rainfall and a greater variation in both rainfall and temperature. The central zone is divided by a north-south line into an eastern area, Tokyo type, in which there is a heavy summer rainfall, and a western area, Niigata type, in which there is a heavier winter precipitation.

In Table 1 is given the average monthly temperature in degrees Farhenheit at Nemuro and Hakodate in the northern zone, Tokyo and Niigata in the central zone, Nagasaki (semitropical) and Taikoku (Formosa tropical) in the southern zone in Japan, and Chico, Calif. The temperatures at Chico are representative of those prevailing in the California rice area.

Inspection of Table 1 shows that the monthly temperatures in the northern zone are much lower than in either of the other zones or at Chico, Calif. The temperature at Chico is higher during the winter months than it is in the central zone, or the southern zone, Nagasaki type. During the summer months the average monthly temperature at Chico is as high or slightly higher, except for August and September, than it is at Tokyo, Niigata, and Nagasaki. Every month in the year is warmer at Taikoku (Formosa) than at Chico, Calif., or Nagasaki, Japan. There is very little difference in the average temperature at Tokyo, Niigata, and Chico during the summer months, and especially during the months of August, September and October. The humidity, however, must be much higher in Tokyo and Niigata than at Chico for the rainfall is a good deal higher during these months.

Table 1. Average monthly temperature in °F[1] at Nemuro and Hakodate in the northern zone, Tokyo and Niigata in the central zone, and Nagasaki and Taikoku in the southern zone of Japan, and at Chico, California

Month	Northern Zone		Central Zone		Southern Zone		Calif.
	Nemuro	Hakodate	Tokyo	Niigata	Nagasaki	Taikoku (Formosa)	Chico
January	22.8	26.4	37.4	34.7	42.8	60.3	45.5
February	23.1	28.3	38.3	34.2	39.9	57.2	49.4
March	27.5	33.3	44.2	40.1	48.6	62.4	53.0
April	37.4	43.5	54.7	50.7	57.9	69.3	58.2
May	43.9	50.7	61.7	59.0	64.2	74.8	64.6
June	49.6	57.6	68.7	66.7	70.9	79.9	72.6
July	57.4	65.3	74.8	74.3	77.9	82.2	78.9
August	63.0	70.3	77.7	77.9	79.9	81.9	77.1
September	59.2	63.3	71.2	70.3	74.1	79.2	71.2
October	50.7	52.5	60.4	59.2	65.8	73.9	62.8
November	39.7	41.5	50.5	48.9	55.0	67.3	52.2
December	29.5	31.5	41.5	39.4	46.2	62.1	45.6
Number of years	33	40	37	31	34	18	Normal

1/ Original table in Sanders article. (See footnote 1) The temperatures are given in Centigrade.

In Table 2 is given the average monthly rainfall in inches at representative places in the northern, central, and southern zones of Japan and at Chico, Calif. Table 2 shows that there is considerable precipitation during every month in the year in all zones. The rainfall from April to September, inclusive, the summer growing season, is abundant in the central and southern zones, and I would think, quite sufficient in the northern zone. The monthly precipitation at Chico, Calif., which is typical of that prevailing in the California rice area, is seen to be very light during the growing months and relatively heavy during the winter months. The total precipitation in California is much lower than that of the Nemuro type, which is a good deal lower than that of the other types represented. The rice harvest months September, October, and November, have much less rainfall in California than in Japan. Even if Japan had large fields it would be very difficult and probably impossible to use modern machinery in rice harvesting, for the fields are seldom dry enough to permit the use of tractors, binders, and other heavy implements.

Table 2. Average monthly precipitation in inches [1] at Nemuro and Hakodate in the northern zone, Tokyo and Niigata in the central zone, and Nagasaki and Taikoku in the southern zone of Japan, and at Chico, Calif.

Month	Northern Zone		Central Zone		Southern Zone		Calif.
	Nemuro	Hakodate	Tokyo	Niigata	Nagasaki	Taikoku (Formosa)	Chico
January	1.12	2.20	2.25	3.80	3.11	3.58	4.96
February	.83	2.27	2.28	4.93	3.22	5.15	3.79
March	1.72	2.52	4.40	4.12	5.12	6.92	3.14
April	2.77	2.73	5.19	4.17	7.74	5.42	1.58
May	3.85	3.15	6.18	3.26	7.09	8.07	.99
June	3.57	3.54	6.06	5.23	11.61	9.50	.41
July	3.38	5.43	5.64	6.18	9.66	8.15	.04
August	3.70	5.09	5.72	5.15	6.99	9.72	.02
September	5.26	6.63	8.29	7.35	8.30	9.18	.60
October	3.47	4.50	7.09	5.76	4.63	4.04	1.20
November	3.12	3.77	3.95	7.19	3.36	2.86	2.65
December	2.44	3.12	2.13	9.16	3.36	3.67	4.22
Number of years	32.51	44.96	59.07	70.61	74.19	76.38	23.60

1/ Original data for precipitation by Sanders was given in MM.

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March	1.72	2.52	4.40	4.12	5.12	6.92	3.14
April	2.77	2.73	5.19	4.17	7.74	5.42	1.58
May	3.85	3.15	5.18	3.26	7.09	8.07	.99
June	3.57	3.54	6.06	5.23	11.61	9.50	.41
July	3.36	5.45	5.64	6.18	9.66	8.15	.04
August	3.70	5.09	5.72	5.15	6.99	9.72	.02
September	5.36	5.65	8.29	7.35	8.30	9.16	.60
October	3.47	4.50	7.09	5.76	4.63	4.04	1.20
November	3.12	3.77	3.95	7.19	3.36	2.86	2.65
December	[illegible].44	3.1[illegible]	2.13	9.16	3.36	3.67	4.22
Number of years	32.51	44.96	59.07	70.61	74.19	75.38	23.60

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Regarding the central zone, Tokyo type, Sanders 1/ says: "This zone comes nearest to the optimum both in temperature and humidity (as defined by Prof. Huntington), 7/ as well as being the most variable on account of the storms. It is interesting to note that this zone includes the most progressive part of Japan where manufactures are springing up, where trade is most vigorous, where the university is the oldest and most energetic, and where the seat of government is situated."

7/World Power and Evolution, Ellsworth Huntington, New Haven, 1919, pp. 58-104.

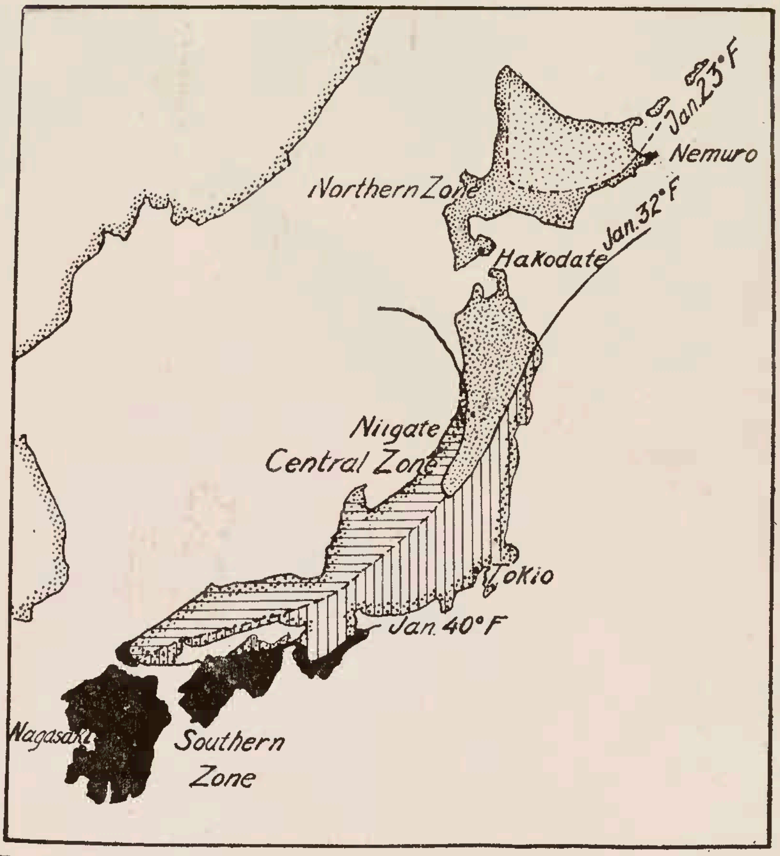

Fig. 17.—Map showing climatic zones. (Isotherms after Tokio Central Meteorological Observatory, Tokio.)

Rice

Agriculture in Japan consists largely of rice growing with the rearing of silk worms as a supplementary occupation. These two crops, rice for food and silk for export, are the outstanding features of Japanese agriculture. Since the population is dense and the available agricultural land limited in area the methods used are intensive, and the area cultivated per family is small. More than one-half of the cultivated land is in rice, and about one-third of all farm families rear mulberries and silkworms in conjunction with other crops.

Size of Farms and Ownership

In 1923, according to the Japan Year Book, 1925, about 35 per cent of the farm families farmed less than 1.25 acres; 34 per cent farmed more than 1.25 but less than 2.50 acres; 21 per cent farmed more than 2.50 but less than 5 acres; 6 per cent farmed more than 5 acres but less than 7.5 acres; and only 4 per cent farmed more than 7.5 acres.

In 1923 about 31 per cent of the farm families were farming their own land; 28 per cent were tenant farmers; and 41 per cent were families owning and leasing land. Leases usually run from 10 to 50 years, but the most common period is from 10 to 12 years.

Kinds of Rice

In Japan and other oriental rice producing countries, there are three main groups of rice, namely, (1) common, low land (2) glutinous, and (3) upland. Glutinous rices are grown on lowland and upland. In 1923, 87 per cent of the total rice acreage in Japan was in common lowland rice, 8.5 per cent in glutinous lowland rice, and the remaining $4\frac{1}{2}$ per cent was in upland rice. In all Asiatic countries the common lowland rice is much more extensively grown than is the upland. The kernels of common rices are normally quite hard and translucent and when properly cooked retain their identity. On the other hand the kernels of glutinous rices are opaque and waxy in appearance and when cooked lose their identity and become a sticky mass. Glutinous rices are used largely in pastries and confections.

1/ In this paper I have added 20 per cent to brown rice when converting it into rough rice, and throughout the paper one koku of brown rice was assumed to weigh 330 pounds. I was told that a koku of brown rice weighs 40 kwan and a kwan is about 8.27 pounds, which makes 330 pounds per koku.

Varieties of Rice

In each of the three groups - common, glutinous, and upland - there are numerous varieties in Japan which are classed according to maturity as early (Wase) midseason (Nakate), and late (Okute). In each of these classes are awned, partly awned, and awnless varieties. In each class there are short-grain , medium-grain, and long-grain

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There are probably more varieties of rice, estimated number 5,000, in existence than of any other cereal crop. In Japan there are hundreds of varieties. I was told by Dr. H. Ando that thousands of varieties had been collected, but many of these were probably identical though grown under different names. Rice varieties not only differ morphologically, but in their soil, water and temperature requirements etc. Therefore, hundreds of rice varieties have apparently come into existence that are adapted to various local conditions in different parts of the world. There are 47 prefectures in Japan, and in each of these prefectures there are one or more varieties recommended for use depending upon local conditions. In those prefectures with a large variety of soils and growing conditions 10 or more varieties may be used, while in other prefectures the conditions may not require more than three to five varieties. The early maturing rices of which Aikoku and Kamenoo are important varieties, are extensively grown in northern Japan. Midseason varieties such as Shinriki, Omachi, Sektori, Ishijiro, Miyako, Takenari, are extensively grown in central Japan and with later varieties such as Ashai etc. also in southern Japan.

A day spent at the Nishigahara Experiment Station at Tokyo with Dr. H. Terao and another day at the Rice Experiment Station at Konōsu near Tokyo gave me an idea of the character and extent of the practical and scientific work that is being conducted with rice by the Imperial

Government. At the Konōsu Experiment Station the nursery included about 1,000 varieties of lowland and upland rices that had been collected largely in Japan, but a few from foreign countries.

The rice investigations at Konōsu include breeding work by hybridization, pure line selection, varietal testing, fertilizer, cultural, and irrigation experiments in the field, and fertilizer experiments in pots and physiological studies in the greenhouses and laboratories.

In the Rice Nursery at Konōsu I saw dwarf rices, partially sterile rices, liguleless rices, and rices with long glumes for the first time. At the Nishigahara Station I was shown rice plants that had been grown vegetatively for several years and some of the plants were "running out" due apparently to disease. At Buitenzorg, Java I was shown similar rice plants by Mr. L. Koch.

It was noted that the rices usually grown in Hokkaido did very poorly at Konōsu, as did our southern rices, Honduras and Carolina. In the greenhouse and laboratory many interesting physiological studies with rice were being conducted as well as fertilizer experiments in pots. It was observed that some rice varieties did well in weak and others in strong solutions; prolonged light appeared to be harmful to all varieties included in the experiments, but to some it was more harmful than to others; some varieties are susceptible and others resistant to the various rice diseases; some rices do better than others when subjected to alternate wet and dry conditions; and in pots and plat experiments nitrogen appeared to give better results than the other commercial fertilizers.

Seed Bed

All lowland rice in Japan is first sown broadcast in a seed bed. The seed beds are if possible located on the best available land and are usually well fertilized and carefully looked after. The land is thoroughly prepared and the seed, after sprouting, is sown in shallow water from April 10 to May 20. About one-fifteenth to one-tenth of an acre of seed bed is required for each acre of land to be transplanted. The seed required per acre varies from 50 to 80 pounds. The rate of seeding depends upon the number of seedlings desired per acre, and this is determined in a measure by the temperature of the air, the variety of rice used, and the fertility of the land on which the seedlings are to be transplanted. As a rule early maturing varieties are sown thicker than midseason and late varieties and on infertile soils, and in cold regions the rice is sown thicker than when it is grown under more favorable conditions. The seed beds are flooded at night and drained during the day time, to expose the soil to the sunlight.

Selection

Rice is normally self-fertilized, however natural crossing does occur. Natural crossing followed by natural selection and human selection, with occasional mutations, are no doubt responsible for the numerous rice varieties that are present in the large rice producing countries of the world. More recently many varieties have been created by hybridization. The varieties of rice differ in dates of maturity, tillering capacity, strength of straw, shattering, disease resistance, size of grain, yield, quality, etc., and the diversity of types furnish excellent material for pure line selection.

In Japan pure line selection ~~work~~ with rice has been in progress for many years and marked increases in yields per acre have been obtained by the replacing of inferior varieties and mixtures with higher yielding selections. Many of the Japanese investigators report that the best pure line selections yield from 5 to 15 per cent more than the varieties from which they were isolated. About 70 per cent of the rice acreage in Japan is sown each year to pure line selections. A mixture of varieties on commercial fields is rarely seen.

The seed rice is often selected by weight or specific gravity by the salt water method and only the heaviest seed is used. At the Yamaguchi Prefectural Experiment Station the average yield per acre, for a 7-year period, of seed selected by the specific gravity method was as follows: selection by wind average yield per acre 2,714 pounds, seed selected at a specific gravity of 1.00, 2668 pounds, at a specific gravity of 1.~~10~~05, 2961 pounds, at a specific gravity of 1.10, 3009 pounds, at a specific gravity of 1.15, 3011 pounds, at at a specific gravity of 1.20, 3274 pounds. This data indicates that such selection is well worth while even though the light and heavy seed are genetically the same.

Observations made while traveling about Japan led me to believe that more than 70 per cent of the rice acreage was sown to pure line varieties. A large part of the remaining 30 per cent of the rice acreage, however, is probably sown to varieties that have been obtained by mass selection, for I was told that all rice growers select their seed in the fields unless it is known to be a pure variety. The seed thus selected in mass year after year could give varieties practically as uniform as are the pure line strains.

In Japan pure line selection work with rice has been in progress for many years and marked increases in yields per acre have been obtained by the replacing of inferior varieties and mixtures with higher yielding selections. Many of the Japanese investigators report that the best pure line selections yield from 5 to 15 per cent more than the varieties from which they were isolated. About 70 per cent of the rice acreage in Japan is sown each year to pure line selections. A mixture of varieties on commercial fields is rarely seen.

The seed rice is often selected by weight or specific gravity by the salt water method and only the heaviest seed is used. At the Yamaguchi Prefectural Experiment Station the average yield per acre, for a 7-year period, of seed selected by the specific gravity method was as follows: selection by wind average yield per acre 2,714 pounds, seed selected at a specific gravity of 1.00, 2668 pounds, at a specific gravity of 1.10, 2961 pounds, at a specific gravity of 1.10, 3009 pounds, at a specific gravity of 1.15, 3011 pounds, at at a specific gravity of 1.20, 3274 pounds. This data indicates that such selection is well worth while even though the light and heavy seed are genetically the same.

Observations made while traveling about Japan led me to believe that more than 70 per cent of the rice acreage was sown to pure line varieties. A large part of the remaining 30 per cent of the rice acreage, however, is probably sown to varieties that have been obtained by mass selection, for I was told that all rice growers select their seed in the fields unless it is known to be a pure variety. The seed thus selected in mass year after year could give varieties practically as uniform as are the pure line strains.

The rice paddies in Japan are very small and usually are surrounded with irrigular narrow levees on which soybeans or other upland crops are grown. In some sections the paddies are separated by straight levees, and these areas resemble a huge experimental tract set out in plats ranging from a tenth to 1 acre in size. There are no fences in Japan, and how the rice farmers are able to locate their various paddies, among the thousands present, was a mystery to me. Many varieties are seen growing side by side - early, midseason, and late varieties - and each is uniform in type, height, date of ripening, etc.

Land Preparation

The small paddies are plowed (See Fig. 1), hoed (Fig. 2), or spaded (Fig. 3) when dry or wet and sometimes in the water. If plowed or hoed when dry the land is harrowed while dry and then water is added to the fields and the land is pulverized by hand or by means of wooden harrows drawn by an ox (See Fig. 4), or horse in the water. Usually one person leads the horse or ox while another looks after the plow or harrow. Those who have no draft animals usually prepare the land entirely by hand. The land is thoroughly prepared and all trash buried with the fertilizers that are applied at this time. The land within the same levees is almost perfectly level. After the soil is thus thoroughly prepared and all growth is destroyed and buried, the fields are ready for transplanting. The low, narrow, wavy levees are seldom broken down, but are kept in good repair. Bermuda grass may grow on the tops of the little levees, but the sides are kept free of grass and are usually sown to beans, grain sorghum, etc. The ditch banks often serve as levees, and they are higher, wider, and much stronger than are the field levees. Public paths and roads often follow these larger levees and ditch banks.

Fig. 1. Plowing rice land in Japan with an ox

By H. Suito

Fig. 2. Preparing a seedbed with a hoe in Japan

By H. Suito

Fig. 3. Spading upland in Japan

By H. Suito

Fig. 4. Harrowing a rice seedbed in the water in Japan

By H. Suito

Implements

The farming tools consist of hoes, of various sizes and weights, spades, either solid or forked, (these are hand tools used to turn up the ground and break the clods) small wooden plows and harrows which are drawn by a horse or an ox, the hetchel and small wooden cylinder with wire teeth for threshing the rice, the hand sickle for harvesting, hand weeders which are pulled or pushed between the rows of rice, and animal weeders which are being tested.

These implements are light and easily moved from paddy to paddy, and while they are often spoken of as being crude they seem to me to be well adapted to the small and scattered paddies upon which they are used. One often sees a farmer going from his home to the field with a plow on his shoulder and the horse or ox being led behind. There would be less excuse for using such small implements if the farmers had all of their land holdings (average $2\frac{3}{4}$ acres) in one tract.

There are several good reasons why our western farm implements are not used in Japan and the principal ones are: (1) the area under cultivation per farm family, 30 per cent or more being less than $1\frac{1}{4}$ acres and the average $2\frac{3}{4}$ acres, are too small for the economical use of modern machinery; (2) the cost of modern implements is prohibitive for farmers with such small areas; (3) good draft animals are not available, and tractors are too costly to be used as motive power; (4) modern machinery would be too heavy to move from paddy to paddy, and (5) over one-half the total land under cultivation is in lowland rice. On much of this land the well distributed rainfall combined with poor drainage often keeps the ground too soft, even if the fields were large enough to effectively use machinery. Then too some of our

implements are wasteful, the grain binders leave a good deal of straw on the ground and waste considerable rice even on dry ground, and the Japanese farmers cannot afford to waste either of these products. Modern threshers are not suited for Japanese conditions. Even if the farmers had them, I doubt if they would be used, because straw passed through a modern thresher is rendered useless, except for packing, bedding, paper, and as a fertilizer. Threshers also break a great deal of rice, while the hand machines do not. Large caterpillar tractors such as are used in the preparation of the rice fields for planting in California and for operating the threshers in harvest would hardly be able to turn around on the ordinary rice paddy in Japan. As the population increases in America we are more apt to adopt the oriental methods than they are to adopt ours as they are now used.

Fig. 5. Building a levee with a "checker" in California

By courtesy of C. F. Dunshee

Transplanting

The seedlings are grown in the seedbeds from 30 to 50 days, and are then pulled, tied in small bunches, and are taken to the fields for transplanting.

As stated before, there are three main factors which determine in a general way the distance between the hills and the number of seedlings per hill in the fields. Early maturing varieties are usually transplanted younger and in rows and hills that are closer together and more seedlings are placed in each hill than when midseason or late varieties are used. The rows and hills also are placed closer together in cold than in warm regions. On infertile soils where little tillering of the plants can be expected the rows and hills are placed closer together and more seedlings are placed in each hill than when grown on more fertile soils.

The following data from the Nagoaka Prefectural Experiment Station illustrate the effect of variety on the rates of transplanting ; early maturing varieties are transplanted in rows 1 foot apart with the hills spaced 8 inches apart in the rows and in each hill are placed four seedlings; midseason varieties are transplanted in rows 1 foot apart with the hills spaced 9 inches apart in the rows and in each hill are placed three seedlings; late maturing varieties are transplanted in rows 1 foot apart with the hills spaced 10 inches apart in the rows and in each hill are placed two seedlings.

Fig. 6. Pulling rice seedlings in Japan for transplanting

By H. Suito

At the Kanazawa Prefectural Experiment Station early, midseason, and late maturing varieties are sown in rows and hills the same distance apart, 1 foot x 7 inches. But for the early varieties they recommend that five seedlings be placed in each hill, for the midseason varieties four seedlings in each hill, and for the late varieties two seedlings in each hill.

The seedlings are pulled up, tied in small bunches and are transplanted in shallow water by hand. Women do most of the transplanting and the hills are set out in straight lines by following a light rope made of rice straw.

Many of the prefectural experiment stations are experimenting with direct seeding in hills and drilled rows. The yields from direct seeding are practically the same as when the rice is transplanted, at some stations a little less, and at others slightly more. The objections to direct seeding are (1) that second crops cannot be grown because the rice must be sown early in the spring, (2) weeds are more difficult to keep under control by direct seeding.

Fig. 7. Transplanting rice in Japan

By H. Suito

Upland Rice

In 1918 all prefectures, except Aomori, grew some upland rice, but upland rice is grown most extensively in the prefectures that have a high summer rainfall. The leading upland producing prefectures in 1918 were in the order of acreage - Ibaragi, Tochigi, Kagoshima, Chiba, Saitama, Kumamoto, Miyazaki, Kanagawa, Gumma, and Tokyo. The upland rice acreage ranged from 1.8 cho (2.5 acres) in Iwate and Hokkaido in 1918 to 29.456 cho in Ibaragi.

The upland rice is sown in rows spaced 1 to 1½ feet apart. The rice is usually sown in continuous rows (not in hills) by hand seeders or simply by hand in a shallow furrow that has been opened to receive the seed. The upland rice fields are located on the foothills and smooth mountain sides where irrigation water is not to be had. Upland rice is keep relatively free of weeds and is cut and threshed just like lowland rice, but the yields per acre are much lower than for lowland rice.

Irrigation and Drainage

Rivers supply 65 per cent of the water used in the irrigation of rice in Japan, reservoirs 21 per cent, and other sources such as ponds and lakes, wells, etc., provide for the remaining lowland acreage. There are no real large irrigation projects. Most of the systems are relatively simple and no doubt could be improved in certain sections. Flat rocks, poles, brush, etc., are often used to partially dam up a stream and raise the water a few feet. The water in the rivers is usually clear. In the fields no boxes such as are used in California to control the depth of water in the checks were observed. Check gates were also absent in many of the irrigation ditches, but where large ditches were used check gates were employed. In the fields the water simply passes over or through the low levees from check to check. Rocks or other material are often used to prevent the levees from washing out at the place where the water passes from a higher to a lower check.

The water is at times lifted from a lower to a higher level by means of a paddle wheel. The paddles fit in a trough through which the water is raised to a higher level, where it is used on the rice fields. The paddle wheels are occasionally operated by a man who treads upon the paddles for days at a time. Wind mills which operate pumps are also used to lift the water in some sections.

Picture mislaid
in reprinting

Fig. 8. A submerged rice field in California

Courtesy of C. F. Dunshee

Fig. 9. Lifting water with a tread wheel in Japan

By H. Suito

In little ravines and at the base of mountains ditches are provided to catch the water and carry it to the rice fields. Terraced rice fields follow up practically all ravines tier after tier until the rougher, steeper lands are reached. Some of the paddies on terraced land are extremely small, occasionally only a few square feet. The terraced land is apparently much less productive than the lower more level lands. In western Japan along the coast of the Sea of Japan the terraces are often 10 or 12 feet high and extend to the very edge of the seashore.

The depth of water held on the rice land ranges from 2 to 5 inches. Deeper water is held in cold than in the warm regions. At some of the prefectural experiment stations $1\frac{1}{2}$ to 2 inches of water was reported to give better results than 3 or 4 inches, while at others deeper water gave the best results. The average depth of water held on the rice fields is probably about $2\frac{1}{2}$ to 3 inches - considerably less than is held in California.

After transplanting water usually is held on the land until the rice is fully headed. The land is then drained. It does not, however, dry out quickly for the rains keep the ground wet until the rice is fully matured. The rains are frequent enough to properly mature the rice, and for this reason the rice land is drained much earlier than is common in California where rains are not depended upon to ripen the crop.

In many sections of the rice area the drainage systems are rather poor. Often the streams which supply water to the rice land cannot be dried up, and as these ditches are located above the level of the rice land it is kept wet and often submerged during even a light rainfall. In a number of places it was observed that during rains the irrigation ditches often became full and overflowed into the rice paddies submerging the land several inches deep, while the poor farmers in mud and water nearly up to their knees were trying to harvest the crops. Parts of the rice area in central and southern Japan appear to have good drainage, that is, from Tokyo south to Nagasaki the drainage with few exceptions appeared good compared with that north from Tokyo to Akita and on parts of the west coast.

Fertilizers

Intensive agriculture based on scientific principles is highly developed in Japan. Two-fifths of the lowland rice area also produces a second crop of barley, wheat, vegetables, or a green manure crop each year. To continuously crop land year after year means that the natural fertility of the soil is certain soon to become depleted, unless fertilization of the land is practiced. Natural manures such as refuse, human excreta, etc. have been used in Japan since early times, and in more recent years the use of artificial fertilizers has become very common. In the early mornings it is a common sight to see four wheeled carts upon which are mounted small barrels filled with human excreta moving from the towns to the farms. This material also is collected when possible in the cities and is sent to the farms. Compost vats or concrete pits are seen on almost all farms where night

soil, manure, refuse, grass, leaves, etc. are turned into manure. Many people are seen cutting grass, weeds, and other herbage on vacant or unused land. This material is used for compost or to apply directly to the land. Literally nothing of food value for man, animal, or plant is wasted.

The rice lands of Japan and in fact practically all, if not all, cultivated land is fertilized. The cost of artificial fertilizers for all cultivated land is about $150,000,000 per year, or about $10. per acre for each acre under cultivation. The natural manures, including night soil farm manures, green manures, refuse, composts, etc. used each year are probably equally as valuable as the artificial manures, so that the value of fertilizers for each acre under cultivation is probably close to $20. per year.

While all crops are fertilized rice and vegetables receive heavier applications of fertilizers than do wheat and barley. Bean cake is extensively used as a fertilizer for rice in Japan. The bean cake used each year is valued at $60,000,000, five-sixths of which is used on rice lands. Nitrogen is often cheaper in ammonium sulphate than in soybean cake. The farmers, however, are better occustomed to the use of the latter.

In Japan with its 7,730,000 acres of rice each year, grown on various soil types, there is not, of course, any standard rate of fertilization for the total area. For in certain soil types nitrogen may be deficient, in others potassium. or phosphorus, and soils are deficient in two and often all three of these elements. The rate of fertilization and the kinds and amounts of fertilizers used vary in different localities and on different soil types within the same section.

At a number of the prefectural experiment stations it was observed that in the fertilizer experiments in pots and in the field plats nitrogen always gave good results. In some places phosphorus was deficient and in other sections potassium. At the Fukushima Prefectural Experiment Station the lack of phosphorus was very marked and was equally as deficient as nitrogen in the fertilizer plats, judging by the poor growth, dark green color, and late maturity of the rice plants on the land that did not receive phosphorus.

In regard to the rate of fertilization of rice lands Prof. G. Daikuhara now of the Imperial University of Fukuoka gave me the following figures:

Heap of manure (compost)	6600 to 9900	pounds per acre
Soybean cake	330 to 900	do
Ammonium sulphate	99 to 165	do
Super-phosphate	330 to 990	do
Wood, straw and hull ashes	660 to 990	do
Lime (once in 3 or 4 years)	990	do
Fish meal or dried fish	330 to 660	do
Human excreta	3300 to 6600	do

The heap of manure, super-phosphate, ashes, and lime are applied before or during the preparation of the fields for rice. One-half of the soybean cake, ammonium sulphate, fish meal or dried fish, and human excreta is applied before or during the preparation of the land for the rice crop, and the remainder is applied after the rice seedlings have been transplanted and become well rooted. On a ton basis the lower rates of application above mentioned amounts to 5.8 tons, and

the higher rate 10.6 tons of fertilizer per acre. The average weight of the rice crop removed from the land, assuming equal weights of grain and straw, is about 7.9 tons.

During my travels about Japan information regarding the fertilization of rice lands was collected at several of the prefectural experiment stations. It would serve no object to present all that data here. However, a few average figures are given below.

Heap of manure	8,250	pounds per acre, average of	11 stations
Bean cake	394	do.	10 stations
Ammonium sulphate	100	do.	6 stations
Superphosphate	270	do.	9 stations
Potash	240	do.	9 stations

The acid phosphate is often applied to the barley or wheat crops and not directly to the rice crop.

Green Manure Crops

Genge, Astragulus sinicus, is extensively grown after lowland rice where drainage and temperature conditions will permit. It is sown broadcast in the standing rice before, or at the time of draining the land for harvesting, and it often makes considerable growth before the winter sets in. On well drained land genge produces from 4,000 to 4,500 pounds per acre, which is often distributed over 4 acres. Soybeans and purple vetch are often used on the upland farms as green manure crops. Wheat on the ridges and soybeans in the furrows are grown together as second crops in some sections.

Weeding

In the northern and colder sections of Japan the rice fields are weeded three times, while in the southwestern parts the fields are weeded five times. The first weeding of the rice fields is usually done about ten days after transplanting. This weeding is done with small hand machines which are pushed in the shallow water between the rows of rice. About 10 days after the first weeding the fields are again weeded. The second weeding is by hand and the weeds which are pulled are pushed into the soft mud to rot. The third, fourth, and fifth weedings, respectively, follow the second at successive intervals of about 10 days. I was told that the first and third weedings were usually done with small hand machines and the second, fourth, and fifth by hand.

The fields are kept almost absolutely free of weeds, and along the levees soybeans are commonly grown. Some of the terraced rice in the mountain regions was often quite weedy, but these were exceptions rather than the rule.

The little hand weeding machines, consisting of a revolving cylinder with small flat protruding teeth, are pushed between the rows of rice. They push some of the weeds into the surface of the mud and loosen up others which float to the surface of the water and decay. They are used while the weeds are still very small and poorly rooted, for such an implement would be useless for large weeds. At some of the prefectural experiment stations they are experimenting with larger weeders that are drawn by an ox, cow, or horse. When these are used the rows of rice must be spaced so that certain rows are far enough apart to permit the animal

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Diseases and Insects

There are a large number of fungous diseases that attack the growing rice crop in Japan. All parts of the plant are subject to attack. Imochi (blast or blight), caused by the fungus Piricularia oryzae, Cov., is the most destructive and costly rice disease in Japan. Goma hagare (leaf spots) are caused by a number of different fungi some of which result in some crop damage each year. A disease of the leaves and stems caused by the fungus Hyprchnus sosakii, Shir., causes considerable loss each season. Many fungi cause leaf and glume spots, but as a rule these are not serious. Green smut, Ustlaginoidea virens, Cke, is very common in Japan and results in considerable loss each season. Black smut, Tilletia horrida, Tak, is present, but not destructive. Shiro-hagare-lyo, Phaeosphaeria oryzae, Miyake, is destructive in some sections. It causes the leaves and glumes to turn white.

The most destructive rice insects in Japan are the stem borers. Chilo simplex, Butler, produces two generations per year in northern Japan and is very destructive there. Schoenobius incestellus, Walker, in southern Japan produces three generations each year and causes a great deal of damage. The borers enter the stalk and feed on the inner tissues. In time the culms are killed, the panicles turn white, and no seed is produced.

The rice borers are partially kept under control by natural enemies. Some parasitic enemies are cultured and turned loose in large numbers to feed upon the two pests. The eggs are often gathered and destroyed, and cultural practices and resistant varieties aid in reducing the damages done by the rice borer in Japan. At one of the experiment stations which was subject to damage by borers they grow a variety of rice on certain tracts that the borers are very fond of, and they collect on this variety almost destroying it, but do much less damage to the other plats and varieties. When a rice variety is grown primarily to attract the borers it is known as a "sacrifice crop."

Harvesting

Rice in Japan is harvested by hand. The hills of rice are held by one hand and the stalks are cut near the surface of the ground with a small hand sickle. The harvested rice is tied in small bundles about 4 to 6 inches in diameter. Rice straw or stalks of rice with the panicles attached are used in tying the bundles. The farmers are very apt in tying these rice bundles and can complete the process in less time than it takes to tell it. On wet muddy ground the bundles of rice when tied are placed on the levees, and later they are hung on drying racks. In some sections drying racks are not needed, and under such conditions whole checks are cut and allowed to dry in the windrow or swath before being tied in bundles. When the rice is dried in windrows large bundles are made, and these may be shocked in the field or put in large piles on the levees.

The harvesting is done by men, women, and occasionally children. At times it is necessary, due to poor drainage and continuous wet weather, to harvest the crop in soft mud and even standing water. When the rice is harvested in the "slush" and water it is often placed on pine boughs or branches of other trees to keep the panicles out of the water, or the rice as it is cut is placed on the levees. Harvesting in the mud, water, and during rains is very unpleasant work. Harvesting in Japan, however, proceeds under all conditions if the crop is mature. There is no loss of grain in harvesting. Every panicle is saved. If there are plants that are not mature when the main crop is harvested they often are left standing, and when mature are harvested separately.

Fig. 10. Harvesting rice on dry land in Japan

By H. Suito

Fig. 11. Harvesting rice in the water in Japan

By H. Suito

Fig. 12. Harvesting rice in California with a rice binder

Courtesy of C. F. Dunshee

In Hokkaido the rice harvest begins about September 15 and lasts for about one month. In the northern zone on the mainland (Hondo) the harvest begins about September 20 and is nearly completed by October 20. In the central zone, the Niigata type, the harvest begins about September 20 and is nearly completed by October 30. In the Tokyo type the harvest begins about September 15 for early rices, but for midseason and late varieties it does not begin until after the middle of October and extends thru November.

The harvesting period in the southern zone is quite similar to that in the central zone, Tokyo type, but continues later. Early maturing rices are grown in the northern zone, Hakodate type, early, midseason, and late varieties in the central zone, Tokyo type, and in the southern zone.

Drying

As has been stated the rice in certain areas is harvested during the rainy season. Rice harvested in wet weather must be dried before it can with safety be shocked or stacked. The rice harvested in wet weather is dried on racks. The drying racks often consist of upright posts and light bamboo cross poles spaced about $1\frac{1}{2}$ feet apart. These racks often extend to a height of 15 to 18 feet. They are located in the fields, on higher ground near the fields, or in the villages. When not located in the fields the rice must be carried to the racks for drying. Men and women usually carry the rice to the drying racks on their backs. Occasionally I saw oxen and horses being used for this purpose, and also ox- or horse-drawn carts where the fields adjoined roads.

On the drying racks the bundles are placed astride the cross poles with the panicles hanging down. Bundles are placed as close together on the cross poles as is possible for the racks are rather expensive. They must be well built to hold so much weight. The panicles of each higher tier of rice overlap the straw of the tier just below, so all panicles are exposed to the drying agencies. This is a very laborious and expensive method of drying rice. However, it is extensively used in northern Japan.

A second type of drying rack that is also used a great deal in the northern prefectures consists of a small pole driven into the ground on the levees. Through this pole at a distance of about 15 inches from the ground is placed a cross bar. A small bundle of rice is then placed astride the upright pole and rests on the cross bar. The next bundle is

Fig. 13. Carrying paddy rice to the drying racks

By H. Suito

Fig. 14. A drying rack for paddy rice in Japan

By H. Suito

placed with the panicles in the opposite direction from those of the first. Then other bundles are placed crosswise to these. By alternating panicles and butts and building in the shape of a cross with the upright pole as a center, these poles will support a great deal of rice. They are in many ways much more convenient than the post and cross pole type described above. The drying rack consisting of the upright pole and cross bar is used extensively in Yamagata, Akita, and Niigata Prefectures.

In some sections trees are grown on the levees or ditch banks to support the cross poles of the drying racks. It is not an uncommon sight therefore to see a wall of unthreshed paddy rice some 10 to 20 feet high beneath such trees.

In southwestern Japan few or no drying racks were used in 1925. In this section drainage facilities are better than in northern Japan, and much of the rice apparently matures after the rainy weather or before it begins. In this section a great deal of rice was seen drying in the swath. After drying, the rice is tied in bundles and shocked or piled on the levees. It is in this section that the highest yields of the best quality of rice are reported to be produced. The climate is semitropical, and the late maturing rice ripens slowly in a rather humid atmosphere. Early maturing rices grown in this section are not, I was told, nearly so good in quality as are the late maturing rices.

Fig. 15. Rice on drying racks in northern Japan

Jones

Picture mislaid
in reprinting

Fig. 16. Shocked rice in California
By courtesy of C. F. Dunshee

Threshing

After the ~~rain~~ rice has been dried as well as possible on the drying racks or in shocks or piles it is threshed. The threshing is all done by hand. There are two types of "threshers" in common use. The old type is a hetchel, consisting of flat pointed steel teeth 8 to 12 inches long set in a wooden frame. The steel teeth, which are 3/4 to 1 inch in width and about $\frac{1}{4}$ of an inch in thickness, are placed in a straight line across a wooden frame and are near enough together to prevent a rice kernel from passing between them. The complete set of teeth is about a foot wide and rests on a frame at an elevation of about 2.5 feet from the ground. The rice is threshed by placing the panicles over the teeth and then pulling the straw back between the teeth. The straw readily passes between the teeth, but the rice seed being larger than the culms at the neck is stripped from the panicles and falls upon a straw mat or in a box beneath the thresher.

Fig. 17. Threshing rice in Japan with hetchels

By H. Suito

The other "thresher" consists of a wooden cylinder 15 to 18 inches in diameter with straight or curved wire teeth protrouding from the cylinder bars. The cylinder is supported by a wooden frame and stands about 2½ feet above the ground. The cylinder is operated by a foot paddle which permits the operator to use his or her hands to hold the small bundles of rice over the revolving cylinder teeth which combs off the rice and leaves the straw undamaged. The cylinder revolves away from the operator, and the rice falls on a straw mat.

This machine can be made in any desired width so that one or two people may feed and paddle the machine at the same time. It too is easily transported from paddy to paddy.

The flail is at times used in threshing, but the foot-power cylinder machine is at present by far the most commonly used. The panicles that are broken off by these machines are separated usually in winnowing baskets from the threshed rice and are then flailed out.

Fig. 18. Threshing rice in Japan with the cylinder foot power thresher

By H. Suito

Fig. 19. Threshing rice from the shock in California

Courtesy of C. F. Dunshee

Drying rice after threshing

On the west coast of Japan, especially in Niigata and Toyama Prefectures, the weather is rainy during and after harvest, and the rice, even though it has been dried on drying racks, often contains 17 per cent of moisture. Rice with a moisture content as high as 17 per cent cannot be expected to keep long if the weather becomes warm. Therefore at the prefectural experiment stations rice drying machines and methods are being tested. One small drying machine with a capacity of about 10 bushels per hour is manufactured in Tokyo and costs 1000 yen ($500). The cost of reducing the moisture content of rice from 17 to 14 per cent with this machine in Japan was 3 cents per bushel. This particular machine uses steam as a drying agent, and the fuel consists of rice hulls. A larger drying machine which uses hot air for drying is manufactured at Osaka. This machine also uses hulls for fuel and has a capacity of 45 bushels per hour and costs about $5000 installed in Japan. The cost of drying the rice is about 3 cents per bushel and the dried rice sells for 20 cents per bushel more than does undried rice. Several of these large driers are now in use in Niigata and Toyama Prefectures. The officials recommend slow drying at low temperatures ranging from 60 to 95 °F. The moisture is reduced from 17 to 12 and 13 per cent in the paddy rice.

If the air is too hot the rice is dried too quickly and becomes brittle and of poor quality. Many of the rice growers dry their rough rice on mats placed in the sun during the clear days, the rice on the mats being raked over or stirred in other ways during the process of drying.

Drying rice after threshing

On the west coast of Japan, especially in Niigata and Toyama Prefectures, the weather is rainy during and after harvest, and the rice, even though it has been dried on drying racks, often contains 17 per cent of moisture. Rice with a moisture content as high as 17 per cent cannot be expected to keep long if the weather becomes warm. Therefore at the prefectural experiment stations rice drying machines and methods are being tested. One small drying machine with a capacity of about 10 bushels per hour is manufactured in Tokyo and costs 1000 yen ($500). The cost of reducing the moisture content of rice from 17 to 14 per cent with this machine in Japan was 3 cents per bushel. This particular machine uses steam as a drying agent, and the fuel consists of rice hull. A larger drying machine which uses hot air for drying is manufactured at Osaka. This machine also uses hulls for fuel and has a capacity of 45 bushels per hour and costs about $5000 installed in Japan. The cost of drying the rice is about 3 cents per bushel and the dried rice sells for 20 cents per bushel more than does undried rice. Several of these large driers are now in use in Niigata and Toyama Prefectures. The officials recommend slow drying at low temperatures ranging from 80 to 95 °F. The moisture is reduced from 17 to 12 and 13 per cent in the paddy rice.

If the air is too hot the rice is dried too quickly and becomes brittle and of poor quality. Many of the rice growers dry their rough rice on mats placed in the sun during the clear days, the rice on the mats being raked over or stirred in other ways during the process of drying.

Dehulling

Practically all, if not all, rice in Japan is dehulled by the farmers before it leaves the farm. The dehulling is usually done by stones, similar in shape, but consisting of clay with lists of hardwood or rubber embedded in it, and much smaller in size than those used in modern rice mills. In some sections the power for operating the dehulling stones is obtained from water wheels. In other cases the stones are operated by hand levers and in still others by small engines or electricity. The mortar and pestle still are used to a certain extent for dehulling the rice, but this is a slow and laborious process. After dehulling the hulls are separated from the brown rice by winnowing and to a small extent by the use of farming machines. The brown rice is placed in bags made of rice straw. Each bag holds approximately 133 pounds of brown rice.

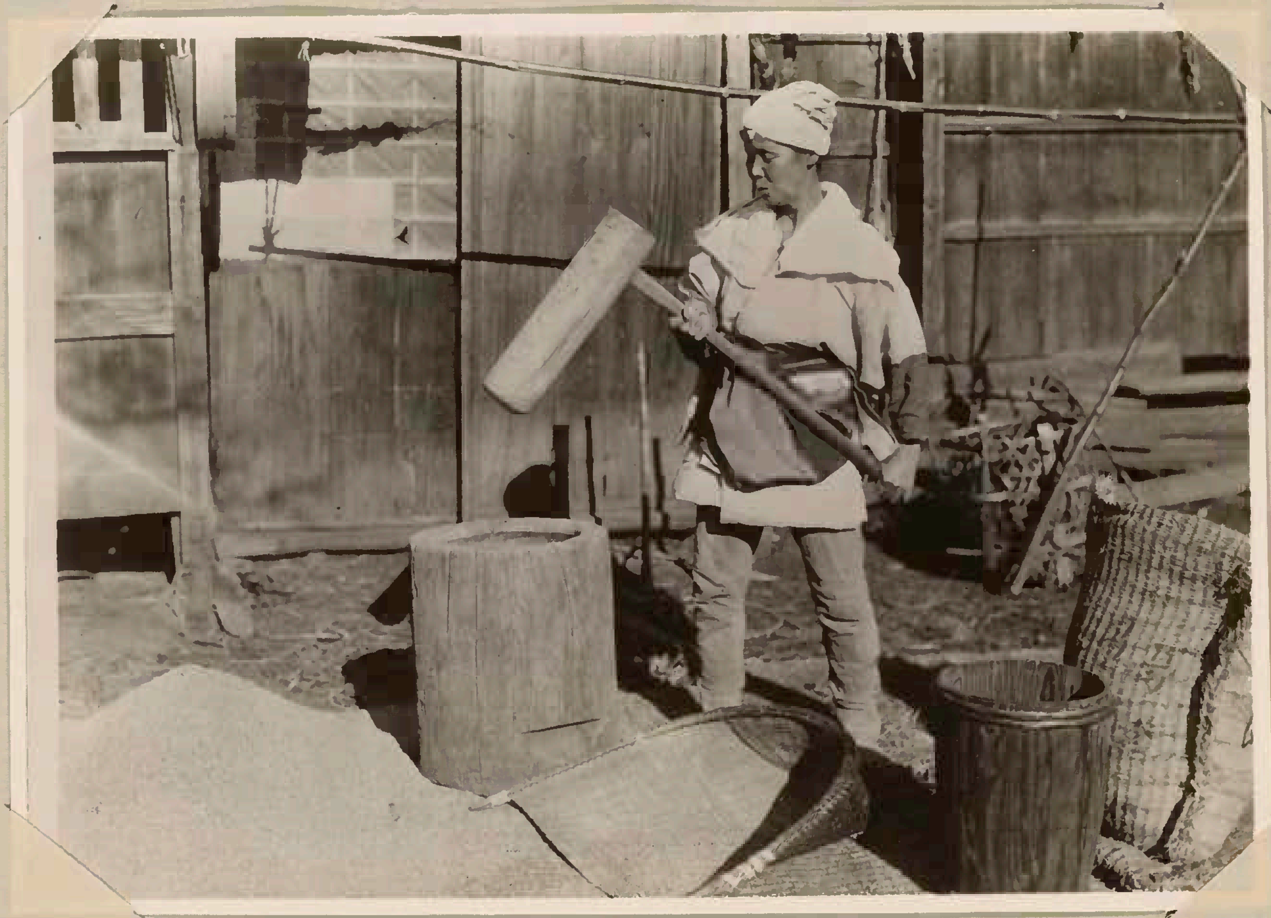

Fig. 20. The mortar and pestle in use in Japan

By H. Suito

Marketing

The growers market their product as brown rice. There are numerous small rice mills in Japan. Each village has one or more and the larger towns many. The rice millers buy brown rice from the farmers. In some of these small mills the wooden mortar and pestle is used to rub off the skin and polish the grain. The pestle is operated by a crank at times by foot, but usually by electricity. Modern rice hullers operated by electricity are most commonly used to polish the grain.

The small mills do not operate continuously, but enough rice is polished to meet the local demand from day to day. The brown rice is said to keep better than polished rice, and the Japanese state that milled rice looses its flavor if kept more than a fortnight before it is consumed. The numerous little rice mills in the villages, towns, and cities, therefore, supply freshly polished rice for their customers from day to day.

In Tokyo and in other large cities there are rice markets where the growers send small samples of the brown rice that they have for sale. On the sample bag is stated the variety, number of bags for sale, and the location of the rice. Buyers visit these markets and purchase the brown rice directly from the growers or their agents. Milled rice may also be purchased in these markets, but most of the transactions are for brown rice.

Cost of Production

The cost of producing rice, according to Professor Nasu (information from H. L. Russell) of the College of Agriculture at Tokyo, on 300 lowland farms in 1923, on which the average yield was 3,754 pounds of rough rice per acre, was $177.50 or $4.74 per hundred. Dr. S. Kato of the Imperial University at Fukuoka, estimates the cost of production at 25 yen per koku, and with an average yield of 20 koku (330 pounds brown rice) per cho (2.45 acres) the cost per hundred of rough rice is about $3.15.

Others stated that it required from 20 to 25 days man labor per tan, which is about one-fourth of an acre, and the average cost of fertilizers is about 10 yen per tan. If labor is figured at $1.90 per day, the average for factory labor in 1923, for 80 days the sum is 152 yen per acre or $76. To this must be added about $20. per acre for fertilizer, and this brings the cost to $96. per acre for just these two items, or $3.05 per hundred for rough rice based on a yield of 3,150 pounds per acre. On the basis of 25 days labor per tan the cost per acre is $115, and if the yield is 3,150 pounds per acre the cost per hundred pounds for rough rice is $3.65, based only on labor and fertilizer costs. Farm labor, however, receives less per day than factory labor.

Uses of Rice Straw

In Japan all rice straw is utilized in some manner. The rice is cut near the ground in order to get as much straw as possible, and it is is cared for almost as religiously as is the rice itself. Modern threshing machines are not used because the farms are too small, and the machines are too costly. However, if threshers were given to the farmers they probably would not use them because modern threshers chew up the straw and render it useless for certain purposes. The ways in which rice straw is used in Japan are numerous and afford an excellent illustration of the old saying that "necessity is the mother of invention."

Mats - Rice straw is used extensively in making mats. In private and many public buildings the floors are covered with mats, the interior of which are made largely of rice straw. These floor mats are 3 feet wide by 6 feet long and from 1 to 2 inches thick. Each room depending upon its size requires three or more mats to cover the floor. Six or eight mats are usually required for an average sized room. All rooms are built so that the floor space will require just a certain number of mats. It is evident, therefore, that a good deal of straw is needed to make the mats that are necessary to cover the floors in homes for 60,000,000 people.

Thatching - In the country, villages, and towns, the homes and other buildings usually have thatched roofs consisting of rice straw. This requires a large amount of straw each year for many new buildings are erected, and many of the old roofs must be repaired.

Fig. 21. Stacking the rice straw after threshing in Japan

By H. Suito

Bags - As stated before the bags in which the brown rice is sold by the farmers is made of rice straw. Each bag holds about 133 pounds of brown rice. It requires about 149,000,000 of these bags to hold the annual rice crop of 60,000,000 koku. These bags, I was told, cost 36 sen in 1925 or about 15 cents each, so the bags necessary for one rice crop are worth $22,350,000, or more than one-half the farm value of the rice crop of the United States in 1923. Of course the bags will last more than one year, and when worn out are used to make paper.

Rope - Considerable rice straw is twisted into rope which is quite pliable and strong and is used extensively for tying crates, boxes, etc.

Paper - Paper mills in Japan use a good deal of rice straw.

Coats - In the country raincoats (minos) are made of rice straw.

Sandals - In their daily work many of the country people wear sandals made of rice straw. Drayage oxen and horses are often shod with rice straw sandals.

Food - Rice straw often is chopped and mixed with more succulent and concentrated foods for live stock. It is also used for bedding of animals.

Brooms - Brooms of poor quality are made of rice straw.

Baskets - Small baskets for carrying various products are made of rice straw.

Packing - Rice straw is used extensively in packing chinaware, crockery, etc.

Bricks - Adobe bricks often have rice straw mixed in as a binder or absorbent.

Bags - As stated before the bags in which the brown rice is sold by the farmers is made of rice straw. Each bag holds about 125 pounds of brown rice. It requires about 149,000,000 of these bags to hold the annual rice crop of 60,000,000 koku. These bags, I was told, cost 30 sen in 1925 or about 15 cents each, so the bags necessary for one rice crop are worth $22,350,000, or more than one-half the farm value of the rice crop of the United States in 1925. Of course the bags will last more than one year, and when worn out are used to make paper.

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Fig. 22. Bags made of rice straw containing brown rice

By H. Suito

Fig. 23. Digging for bamboo sprouts in Japan. The larger gentleman is wearing a rain-coat made of rice straw. By H. Suito

Hedges - Rice straw is used as a windbreak to protect young plants where the soil has a tendency to be shifted by the wind.

Fuel - Rice straw is used as fuel and the ashes spread on the soil as a fertilizer.

Mulch - Rice straw often is used as a mulch.

Fertilizer - The straw that is not used in other ways is returned to the soil as a fertilizer. It may be composted with other material or plowed under directly. When plowing the straw under the farmers are very careful to get it well buried in the soil. Straw is naturally more valuable near the large cities. It is estimated that the rice straw is worth about $2. per acre. As the above uses indicate none of the rice straw is wasted or burned in the fields as is done in California. The yield of rice straw in Japan ranges from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre.

Yields

The yields of rice in Japan rank next to that of Spain and equal to that of Italy, the two countries of highest acre production. The density of population and shortage of tillable land has made it necessary to increase yields per acre as fast as possible.

In Table 3 is given the average acreage, production, consumption, population, and per capita consumption of rice in Japan proper, by 5-year periods from 1878 to 1922, inclusive.

Inspection of Table 3 shows that there has been a gradual increase in acreage and a rapid increase in production, consumption, population, and per capita consumption during this 44-year period. In comparing the 5-year period from 1878-1882 with that of 1898-1902 there was a 11 per cent increase in acreage; 42 per cent increase in production; 50 per cent increase in consumption; 21 per cent increase in population; and 24 per cent increase in per capita consumption.

Comparison of the 5-year period ending in 1902 with that ending in 1922 shows that there was a 10 per cent increase in acreage, 39 per cent increase in production, 48 per cent increase in consumption, 27 per cent increase in population, and 16 per cent increase in per capita consumption. The percentage increase for each item is not markedly different during the two 22-year periods.

In comparing the 5-year period ending in 1882 with that ending in 1922 there was a 22 per cent increase in acreage, 98 per cent increase in production, 121 per cent increase in consumption, 54 per cent increase in population, and a 43 per cent increase in per capita consumption.

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Comparison of the 5-year period ending in 1902 with that ending in 1922 shows that there was a 10 per cent increase in acreage, 39 per cent increase in production, 48 per cent increase in consumption, 27 per cent increase in population, and 16 per cent increase in per capita consumption. The percentage increase for each item is not markedly different during the two 22-year periods.

In comparing the 5-year period ending in 1882 with that ending in 1922 there was a 22 per cent increase in acreage, 96 per cent increase in production, 121 per cent increase in consumption, 54 per cent increase in population, and a 43 per cent increase in per capita consumption.

Table 3. Total acreage, production, consumption of rice, population, and per capita consumption of rice in Japan proper by 5-year periods from 1878 to 1925, inclusive

By 5-year periods	Acreage in cho	Production in koku	Consumption koku	Population	Per capita consumption koku
	(1000)	(1000)	(1000)	(1000)	
1878-1882	2,548	29,812	28,774	36,226	.794
1883-1887	2,617	33,785	31,615	38,041	.830
1888-1892	2,737	38,860	38,284	39,787	.962
1893-1897	2,775	37,673	39,684	41,507	.957
1898-1902	2,836	42,480	43,074	43,870	.981
1902-1907	2,886	46,286	48,336	46,576	1.038
1908-1912	2,957	50,588	52,617	49,538	1.063
1913-1917	3,055	55,242	57,069	53,001	1.076
1918-1922	3,120	58,921	63,571	55,835	1.139
1923	3,148	55,444	66,736	57,741	1.156
1924	3,143	57,170	65,789	58,427 (Est.)	1.126
1925	3,154	59,710		59,737	
1926	3,156	55,531			

Cho = 2.45 acres
Koku = 330 pounds ~~of brown rice~~
Source largely rice crop statistics in Japan. Department of Agriculture and Commerce, Food Division, 1924.

The increase in acreage is lagging far behind that of increase of population and consumption, but the total yield has almost doubled. This indicates that yields per unit of area have been markedly increased during these various 5-year periods. The per capita consumption has increased nearly twice as fast as the increased acreage, but slower than the total production.

Between 1878 and 1900 there was a 10 per cent increase in acreage, a 70 per cent increase in production, and a 12 per cent increase in population. It is apparent that at this time a good deal of progress had been made in increasing the yields per acre. From 1900 to 1925 there was a 15 per cent increase in acreage, a 39 per cent increase in production, and a 50 per cent increase in population. In this period less progress has been made in increasing the total production than in the period from 1878 to 1900, but the population, due probably to better sanitation, has increased much more rapidly during the second period.

During the 47-year period from 1878 to 1925 the increase in the rice acreage was 26 per cent, production 136 per cent, population 68 per cent, and the per capita consumption 42 per cent (1878-1924).

In Table 4 is given the acreage by 5-year periods from 1878-1922, inclusive, in common, glutinous, and upland rice, and the yield per tan and average yield for all kinds.

Table 4. Acreage in cho and yield per tan for common, glutinous and upland rice in Japan, by 5-year periods from 1878 to 1922, inclusive

By 5-year periods	Acreage in cho			Yield per tan			Average
	Common	Glutinous	Upland	Common	Glutinous	Upland	
				koku	koku	koku	koku
1878-1882	2,311,300	224,991	14,575	1.181	1.079	.611	1.168
1883-1887	2,359,553	225,247	32,316	1.305	1.224	.642	1.290
1888-1892	2,442,412	258,923	35,985	1.439	1.340	.735	1.420
1893-1897	2,454,063	267,683	53,473	1.383	1.265	.681	1.358
1898-1902	2,493,739	266,815	75,505	1.531	1.376	.838	1.498
1903-1907	2,543,702	262,714	79,841	1.641	1.475	.835	1.604
1908-1912	2,601,444	261,649	94,085	1.749	1.589	1.003	1.711
1913-1917	2,673,044	256,126	125,688	1.855	1.717	.994	1.808
1918-1922	2,721,835	258,588	139,619	1.938	1.806	1.070	1.888

Cho = 2.45 acres
Koku = 330 lbs. of brown rice
Tan = .245 of an acre

Table 4. Acreage in cho and yield per tan for common, glutinous and upland rice in Japan, by 5-year periods from 1878 to 1922, inclusive

By 5-year periods	Acreage in cho			Yield per tan			Average
	Common	Glutinous	Upland	Common	Glutinous	Upland	
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1878-1882	2,311,300	224,991	14,575	1.161	1.079	.611	1.168
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1893-1897	2,464,063	267,683	53,473	1.383	1.265	.681	1.358
1898-1902	2,493,739	266,815	75,505	1.531	1.476	.838	1.498
1903-1907	2,543,702	262,714	79,641	1.641	1.475	.853	1.604
1908-1912	2,601,444	261,649	94,085	1.749	1.589	1.003	1.711
1913-1917	2,673,044	256,126	125,688	1.855	1.717	.994	1.808
1918-1922	2,721,835	258,589	139,619	1.929	1.808	1.070	1.888

Cho = 2.45 acres
Koku = 330 lbs. of brown rice
Tan = .245 of an acre

Comparing the 5-year period 1878-1898 with that of 1898-1902 there was an increase in acreage for the common rice of 8 per cent, for the glutinous rice 19 per cent, and for the upland rice 407 per cent. The increase in acreage for the 5-year period 1898-1902 compared with the 5-year period 1918-1922 was 9 per cent for common rice, a decrease of 3 per cent for glutinous rice, and an increase of 84 per cent for upland rice. The increase in acreage for the 5-year period 1878-1882 compared with the 5-year period 1918-1922 was 18 per cent for common rice, 15 per cent for glutinous rice, and 833 per cent for upland rice.

These figures show that the acreages in the common and glutinous rices, which are grown under irrigation, are increasing very slowly, but in the upland crop, which is of minor importance, for only about 5 per cent of the total acreage is in upland rice, which yields poorly, the increase is large.

In the 5-year period ~~from~~ 1878-1882 the rice acreage consisted of 91 per cent common lowland rice, 8.8 per cent glutinous lowland rice, and only .2 of 1 per cent upland rice. During the 5-year period 1918-1922, 87 per cent of the rice acreage was in common lowland rice, 8 per cent in glutinous lowland rice, and 5 per cent in upland rice.

Comparing the 5-year period ending in 1882 with that ending in 1902 the increase in yield of the common rice was 30 per cent, glutinous rice 28 per cent, upland rice 37 per cent, and the average for all kinds 28 per cent per acre. Similar increases in yields are noted for the 5-year period 1898-1902 compared with 1918-1922. Comparing the 5-year period 1878-1882 with that of 1918-1922 the yield of common rice was increased 64 per cent, glutinous rice 68 per cent, upland rice 75 per cent, and

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In Table 5 is given the acreage and production of rice in the largest producing prefectures in 1923. In the United States total production varies from 4,000,000 to 4,500,000 koku of brown rice per year, or about the quantity grown in Niigata and Nagano Prefectures.

Many factors have no doubt each helped to increase the acre yields of rice in Japan. Probably the two most important have been improved seed and the increased use of natural and artificial fertilizers. The extensive use of improved seed - pure line selections - and the use of fertilizers have been discussed and need not be reported here. It would not be just, however, to credit the increase in yield to these two factors alone, for improved cultural methods, better irrigation and drainage facilities, and a more enlightened rural population have no doubt been important factors in contributing to the increased acre production.

The average acre yield of rough rice in the United States, in California, and in Japan for the 3-year period 1923-1925, was 1,718 pounds, 2,220 pounds, and 2,951 pounds, respectively.

Table 5. Acreage, total production, and yield per tan for the leading rice producing prefectures in Japan in 1923

Prefecture	Acreage cho	Production in koku	Yield per tan in koku
Niigata	175,531	3,000,055	1.709
Fukuoka	112,684	2,279,012	2.022
Hyogo	108,358	2,101,026	1.939
Chiba	117,646	1,962,553	1.669
Ibaraki	126,183	1,936,444	1.552
Yamagata	91,427	1,890,717	2.068
Aichi	100,682	1,884,276	1.872
Akita	102,039	1,806,460	1.771
Okayama	88,046	1,600,649	1.819
Fukushima	98,190	1,585,200	1.614
Toyama	79,764	1,535,046	1.924
Kumamoto	83,882	1,500,989	1.789
Hokkaido	111,716	1,488,186	1.332
Nagano	69,774	1,441,389	2.066

Cho = 2.45 acres
Koku = 330 pounds of brown rice
Tan = 0.245 acres

Consumption

Referring again to Table 3 last column it is observed that the per capita consumption of rice in Japan has steadily increased with the increased yields per acre. The average per capita consumption for the 5-year period ending in 1882 was 262 pounds; for the 5-year period ending in 1902 it was 324 pounds; and for the 5-year period ending in 1922 it was 376 pounds. Comparison of the 5-year period 1878-1882 with that of 1918-1922 shows that the per capita consumption has increased 43 per cent. These figures indicate that rice now holds a more important place in the daily diet than it formerly did. The upper classes have always eaten rice, and with the rapid industrial development of Japan and the increase in wages more people are now able to eat rice than was formerly the case, and since the eating of rice is considered a mark of respectability it is eaten by all who can afford it. Furthermore the Japanese people are particularly fond of their own rice, and only the poorer people can be induced to eat the cheaper export rices from southern Asia.

Japan is an inland empire with a very limited area of tillable land - less than 21 per cent - and a surplus population whose staple food is rice. It is impossible to grow sufficient rice on the area available to meet the needs of the present and increasing population. As was stated above, the Japanese prefer their own type of rice, and California grows short-grained Japan rice in considerable quantities and at reasonable prices, if of good quality, should (and has this year 1927) find a ready market in Japan.

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Below are given the prices of various rices at the wholesale market at Kobe on January 16, 1927. 1/

Variety	Price per 100 pounds
Brown rice	
Native, best	$6.03
middle	5.70
lowest	5.30
Korean, best	5.23
middle	5.10
lowest	4.94
California (U.S. No. 1)	4.97 (estimated)
Formosan, Japan type	4.74
Formosan, native	3.71
Rangoon, No. 1	3.38
Saigon, No. 1	3.34
Siam, No. 1	3.96

1/ Data from U.S. Department of Agriculture, Bureau of Agricultural Economics, February 28, 1927.

It is estimated that there are 1,750,000 acres of waste land in Japan which can be reclaimed and used for rice growing. Reclamation, however, is a slow process and has been under way for some time, and yet production is not keeping pace with the increase in consumption and increase in population. As the population increases and civilization advances fields are used for home and factory sites, railways, roads, ditches, etc., so it takes a fair increase in farm acreage each year to even maintain a constant area in crops. The yearly increase in the rice acreage is about 25,000 acres which produces enough rice to meet the needs of only about 150,000 people or about one-fifth of the yearly increase in population at the present rate of per capita consumption.

A great deal has been accomplished in increasing the acre yields of rice in Japan in the past, but future increase in yields per acre will no doubt come very slowly, as excellent rice varieties are now used on a large percentage of the acreage, and fertilizers, natural and artificial, are extensively used.

Since about 1900 Japan has had to import rice in rather large quantities for home consumption, and the imports are increasing from year to year. The average imports of rice for the 5-year period ending in 1912 was about 2,250,000 koku (330 pounds brown rice), for the 5-year period ending in 1917, 2,750,000 koku, and for the 5-year period ending in 1922, 5,750,000 koku.

During the 5-year period ending in 1912 about 1,000,000 koku of the imports were from Chosen (Korea) and Taiwan (Formosa); for the 5-year period ending in 1917 about 2,000,000 koku; and for the 5-year period ending in 1922 about 3,500,000 koku. These import figures are convincing proof that rice production in Japan is not keeping pace with the increased consumption for very little rice is exported.

Future Yields

It is to be expected that the yields of rice in Japan will probably increase very slowly in the years to come for during the past few years the acre yields have remained about the same. The Imperial Agricultural Experiment Stations and a number of the prefectural agricultural experiment stations have entered or are entering upon an intensive improvement program by means of hybridization. Material for hybridization work is being collected in various rice growing countries, and an effort is being made to create varieties with straw stiff enough to stand up and produce good crops on land that is heavily fertilized; varieties that are resistant to diseases of various kinds; and varieties that are more resistant to alkali.

If such varieties can be created, and no doubt they can be in time, increased yields per acre may be obtained and the total production of rice increased. Plant nutrition studies are not being neglected, and the combined studies of plant nutrition and hybridization at least have possibilities.

In traveling about Japan one gets the impression that every foot of the arable land is in use. There is some idle land bordering on the rivers, but apparently these rivers often overflow their banks which makes the farming of this land too hazardous. The foothills and especially the ravines where water is available are terraced and sown to rice, and where water is not available dryland crops are grown on the foothills and sides of the smoother mountains. In some sections rough mountain sides are terraced and sown to dryland crops such as buckwheat, sweet potatoes, eggplants, maize, grain sorghum, millet, wheat, barley, etc. The terraced hills about Nagasaki in southwestern Japan are very pretty.

The Japanese have a strong nationalistic feeling, and they do not like to leave Japan for other countries. Japan acquired control of Taiwan (Formosa) in 1898, and yet in 1923 therewere only 182,000 1/ Japanese in Taiwan or about 5 per cent of the population. Chosen (Korea) came into the possession of Japan in 1910, and the Japanese officials have encouraged their people to go to Chosen and develop the country, but there were only 412,000 Japanese in Chosen in 1924, or about 2¼ per cent of the population. The Japanese present in both of these territories, after all these years, are not equal in numbers to the increase of population in Japan proper for one year. There are only 590,000 Japanese in all foreign countries, and most of these are in Asiatic countries.

1/ Year Book of Japan in 1926

Other Food Crops

Besides rice Japan proper grows other food crops in considerable quantity as is shown in Table 6. It is observed in Table 6 that the acreage in wheat, maize, potatoes, horsebeans, and peas, have increased during the past 15 years, while the other crops listed have decreased in acreage. In 1924 there were about 1,500,000 acres of wheat and barley grown as second crops on rice land and over 2,000,000 acres on upland. Naked barley is much more extensively grown on rice land than hulled barley or wheat, probably because it is used more extensively as food in Japan than are hulled barley and wheat. Naked barley mixed with rice is a better ration than rice alone, and those who use the mixture are, I was told, much less likely to be troubled with beriberi. Other food crops grown include an assortment of vegetables and fruits, and of course fish is used in large quantities.

Then too Japan grows such fiber crops as jute, hemp, sesame, rush, flax, and cotton in small quantities, and silk in large quantities. There are well over 1,000,000 acres of land on which mulberry trees or seedlings are grown by one-third of all farm families. The mulberry leaves are fed to silk worms that are cared for largely by the women folks. The income from silk cocoons is about one-fifth of the country's agricultural income and ranges from $250,000,000 to $300,000,000 per year. The United States takes about 85 per cent of Japan's silk and silk textile exports. Tea is also grown on quite a large acreage, and the surplus largely comes to America.

Table 6. Acreage, production in koku, and yield per acre for important food crops in Japan for the years 1908 and 1923, respectively

Crop	Acreage in cho		Production in koku		Yield per acre in pounds	
	1908	1923	1908	1923	1908	1023
	(1000)	(1000)	(1000)	(1000)		
Wheat	450	488	4,112	5,192	1,186	1,292
Barley	641	478	9,444	7,595	1,305	1,447
Naked barley	689	561	5,789	5,856	(60) 1,336	1,268
Buckwheat	166	120	1,234	1,037	725	840
Maize	53	55	637	652	1,374	1,344
Foxtail millet	201	119	2,280	1,510	1,146	1,285
Barnyard millet	61	40	814	675	1,342	1,708
Proso millet	31	24	335	248	808	1,176
Sweet potatoes	304	295	29,750	31,462	10,696	12,938
Potatoes	61	97	4,278	6,316	8,537	7,909
Soybeans	496	425	3,893	3,434	952	981
Azuki beans	140	136	475	889	759	794
Horse beans	42	44	440	508	1,285	1,402
Peas	30	48	268	440	1,099	1,113

Cho = 2.45 acres
Koku = 330 pounds

Land Values

According to the Year Book of Japan for 1926 the legal price of paddy and upland as assessed decades ago are still in force, so that at present it is much below the market price. The Hypothec Bank of Japan in March, 1925 gave the average assessed value per acre of medium class paddy and upland as $1143 and $690, respectively. The maximum assessed value for paddy land was $1508, and the minimum was $796 per acre. The maximum and minimum assessed value for the upland was $998 and $436 per acre, respectively.

The market value of land increased materially during the World War and in October, 1919 medium paddy land was valued at $1428 per acre, or about two and one-half times the prewar price. By the spring of 1920 the market value had declined to about $1224 per acre. The dissatisfaction of the rural population since the deflation began has much affected the market of real estate. Farm mortgages are increasing, and money rates are high. The Hypothec Bank of Japan placed the market value of paddy land in 1924 at $1159 per acre, and upland at $696. These average values include Hokkaido and Okinawa where land values are far below that of the other prefectures.

The assessed value of rice lands in California range from $40 to $60 per acre, and the market price varies from $50 to $100 per acre. The market value of Japan's paddy land is as high as the fully developed, best bearing orchard lands in California. On this high priced paddy land the Japanese farmers obtain average yields of about 3,100 pounds of rough rice per acre, compared with about 2,400 pounds in California.

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Rents

In March, 1925 the Hypothec Bank reported that the rental paid for medium grade paddy land ranged from 1,441 to 1,696 pounds of brown rice per acre. The cash rental for upland ranged from $39 to $50 per acre. The cash rental of rice land in California ranges from $15 to $25 per acre, and on crop rental the landowner usually gets one-third of the crop if he pays for the irrigation water and one-fourth if the tenant pays the water charges. There is little wonder that landowners in Japan are having some trouble in securing tenants for their farms with such high rents and wages for labor increasing.

Price of Rice

In 1921 the necessity of stabilizing the price of rice brought into existence a rice control section of the Ministry of Agriculture and Forestry which is authorized to buy, sell and store rice on government account. When the rice market shows extremes the Control Section buys or sells rice, and trys to keep the price from going too high or too low. It aims, I was told, to keep the price of rice between 30 and 50 yen per koku, or from $4.50 to $7.50 per hundred for brown rice. The program includes the erection of state warehouses at a number of the principal centers of distribution, and at present the warehouses at Tokyo have a capacity of 300,000 koku, Osaka 200,000 koku, and at Moji and Sakata in southern Japan 50,000 koku each. The Rice Control Section buys and sells both domestic and foreign rice.

I visited the government warehouses at Tokyo. They are built of brick or concrete and have water and rail transportation facilities. There are sheltered electric conveyors which carry the rice in straw bags from the boats to the warehouses. In the warehouses the rice is piled on poles that keep the bags from coming in contact with the floor in tiers 13 to 15 bags high. They informed me that the rice keeps better in straw than in bags of other material. The warehouses are equipped with piling machinery the same as is used in the States.

The government is also conducting experiments on a large scale to determine the best temperature, humidity, etc. for the storage of rice. Then too a great deal of work is being done on weevil control in the stored rice. The officials are very enthusiastic about chloropicrin for the control of weevils and other insects, and have large rooms in which 40,000 bags of rice can be treated for weevils at one time. One pound of chloropicrin is used for each 1,000 cubic feet of air space, the temperature is held at 28° C., and the rice is treated for 48 hours. At lower temperature longer exposure is needed to kill the insects. The treatment does not effect the quality of the rice.

The weevil (*Calandra oryzae*) is very troublesome both in the country and city warehouses. There are two forms of this weevil in Japan, according to officials, a large and a small strain. In the country and at lower temperatures the large strain is most active, while in the city warehouse and at higher temperatures the small strain is most active.

Enlarging the Farms

The farms in Japan are very small, the average being about $2\frac{3}{4}$ acres. They are not only small, but each farmer does not have all of his land in one tract. A farm consists of various little plats located in different places. Each little tract, if lowland, is surrounded by low levees, and the plats are often exceedingly small and often poorly drained. Since 1900 government officials have been encouraging in various ways the adjustment of farms. The adjustment aims to have, according to the Year Book of Japan, rectangular paddies or checks at least one-fourth of an acre in size, but not over 1 acre; to have each farmer own his land in one tract, and to increase the yields by improved drainage. It is estimated that the adjustment will lead to a 15 per cent increase in yield, and that about 3 per cent more land will be available for cultivation as a result of having fewer levees and less waste land. A great deal of progress has been made in the adjustment program,, and the adjusted areas look like huge experimental farms divided into rectangular plats of different sizes. The average cost of this work to the end of 1922 was 23 yen per tan (.245 of an acre) which is a relatively large sum. The adjusted areas have better irrigation ditches, roads, and drainage facilities than the unadjusted areas, and stock can be used much more efficiently on the rectangular fields.

List of Experiment Stations

Each prefecture in Japan maintains, in conjunction with the Imperial Government, a prefectural agricultural experiment station, and in some of the prefectures there are also branch or substations. There are also imperial agricultural experiment stations operated usually in connection with the imperial universities.

The imperial universities and experiment stations are located at Tokyo, Kyoto, Sendai, Fukuoka, and Sapporo. There are also other stations operated by the Government for special crops, such as silk, ~~and~~ tobacco, etc. Extensive rice experiments are being conducted by the Government at the Omagari and Konsu Stations, as well as at the imperial agricultural experiment stations.

The locations of the prefectural experiment stations are:

	Prefecture	Location
Tohoku district	Hokkaido	Kotoji Mura, Sapporo Gun
(Northeastern part)	Aomori	Kuroishi, Minami Tsugaru Gun
	Iwate	Honguu Mura, Iwate Gun
	Miyagi	Iwanuma, Natori Gun
	Akita	Asahigawa, Minami Akita Gun
	Yamagata	Yamagata City
	Fukushima	Koriyama City
Kwanto	Ibaraki	Sakato Mura, Higashi Ibaraki Gun
(Eastern)	Tochigi	Imaizumi cho, Utsunomiya
	Gumma	Maebashi
	Saitama	Urawa
	Chiba	Miyako Mura, Chiba Gun

	Prefecture	Location
	Tokyo	Tachikawa, Kita Tama Gun
	Kanagawa	Tamanawa Mura, Kamakura Gun
Hokuriku	Niigata	Nagaoka
(Northland)	Toyama	Toyama
	Ishikawa	Kanazawa
	Fukui	Fukui
Chubu district	Yamanashi	Kofu
(Central provinces)	Nagano	Nagano
	Gifu	Shichigo Mura, Matosu Gun
Takai district	Shizuoka	Shizuoka
(Eastern Sea)	Aichi	Anjo, Hekkai Gun
	Miye	Shirako, Kage Gun
Kina district	Shiga	Zeze, Shiga Gun
(Central part)	Kyoto	Shimokamo, Kyoto
	Osaka	Tomomatsu Mura, Senhoku Gun
	Hyogo	Akashi
	Nara	Shirokashi Mura, Takaichi Gun
	Wakayama	Miya Mura, Kaiso Gun
Seibu district	Tottori	Tottori
(Western part)	Shimane	Shioji Mura, Hinokawa Gun
	Okayama	Okayama
	Hiroshima	Saijo, Kamo Gun
	Yamaguchi	Ouchi Mura, Yoshiki Gun
Shikoku district	Tokushima	Kamona, Meito Gun

	Prefecture	Location
(Shikoku inland)	Kagawa	Takamatsu City
	Ehime	Dogo, Onsen Gun
	Kochi	Nagaoka Mura, Nagaoka Gun
Kyushu district	Fukuoka	Fukuoka City
	Saga	Saga City
	Nagasaki	Isahaya, Kita Takaki Gun
	Kumamoto	Demizu Mura, Ataku Gun
	Oita	Oita City
	Mizazaki	Miyazaki City
	Kagoshima	Kagoshima City
Okinawa	Okinawa	Yoshinowan Mura, Nakami Gun

At practically all of these prefectural experiment stations rice investigations is one of the major projects.

CHOSEN (KOREA)

The total area of Chosen is 85.228 square miles (54,546,000 acres) or about three-fifths as large as Japan proper. Korea is a mountainous country like Japan, and in the southern part the mountains are barren, except for young trees that have been set out in recent years. The hill sides are scarred and pitted as a result of erosion during heavy rains, and they are desolate in appearance. Floods are common during periods of heavy precipitation, for there is no vegetation to help retain the moisture. In northern Korea the mountains are covered with natural forests. There is a good deal of waste land along the rivers consisting of swampy, sandy, and rocky soil which is not used for cultivated crops. Rocks are removed from the land in some instances to make room for a few paddies of rice or upland crops. There is some terraced land in rice, but not nearly so much as in Japan. The crops are usually confined to the valleys and the costal plains. The most productive rice areas are located in the south and southwestern parts of Korea.

The farms and farm buildings indicate that the Koreans lack the industriousness, thriftiness, and progressiveness that is so characteristic of the farmers in Japan. The Korean fields are not so well tilled, weeds are more in evidence, irrigation and drainage systems are not developed, nor is the value of good seed and fertilization of the land appreciated as in Japan.

Population

The population of Korea in 1925 was about 19,500,000, and the number of households was 3,721,000. In 1917, 82 per cent of the population were engaged in agriculture. There were in that year 2,642,000 farm families with an average of 5.3 persons per family or a total rural population of 13,889,000. Later figures regarding the number of farm families are not available to me. But if we assume that 80 per cent of the population were engaged in agriculture in 1925, and that the average size of the farm families were the same as in 1917, then there would be 2,943,400 farm families with a total population of 15,600,000 people. The average size of the farms is about 3½ acres, or larger than in Japan.

The farmers live in little low mud or adobe huts covered with rather flat thatched roofs. There are no trees, flowers, or lawns to improve the appearance of the desolate farm yards. The houses are usually surrounded by a mud or stone wall several feet high which adds to the unattractiveness of the surroundings.

Rice

Rice is the staple crop and occupies over one-third of the cropped area. Common, glutinous, and upland rices are grown in Korea as in Japan. The area sown to common, glutinous, and upland rice and the yields per acre for each group are given in Table 7.

Fig. 24. Typical male attire in Korea

Jones

Fig. 25. Plowing with an ox in Korea

Table 7. Acreage and yield per acre of common, glutinous, and upland rice in Korea by 5-year or shorter periods from 1910 to 1923, inclusive

Period	Acreage in cho*				Yield per acre (rough rice)			
	Common	Glutinous	Upland	Total	Common	Glutinous	Upland	Average
1910-1914	1,372,352	89,188	15,475	1,422,015	1,353	1,212	1,041	1,340
1915-1919	1,421,736	86,394	18,249	1,526,378	1,466	1,287	936	1,450
1920-1923	1,449,703	80,460	18,661	1,548,575	1,565	1,377	1,062	1,550

* 2.45 acres

During the 5-year period ending in 1914 roughly 93 per cent of the area was in common rice, 6 per cent in glutinous rice, and 1 per cent in upland rice. For the 4-year period ending in 1923 the rice acreage consisted of 94 per cent common, 5 per cent glutinous, and 1 per cent upland rice. Comparing the acreage of the 5-year period ending in 1914 with that of the 4-year period ending in 1923 there was a 10 per cent increase for common rice, a 11 per cent decrease for glutinous rice, a 23 per cent increase for upland rice, and an average increase in acreage for all kinds of 9 per cent.

In yield per acre the increase for the 4-year period ending in 1923 over the 5-year period ending in 1914 was for common rice 16 per cent, for glutinous rice 14 per cent, for upland rice 2 per cent, and for all kinds 15 per cent. The 15 per cent increase in the acre-yields of rice is quite a noteworthy achievement in a period of some 13 years, and no doubt much higher yields per acre will be obtained in future years under Japanese guidance. The average acre-yield of rice in Korea is even now as low as that obtained in Louisiana and Texas. The increases noted above in the yields of Korean rice are due to the use of improved Japanese and native varieties, improved irrigation facilities for part of the rice area, and to better farming practices that have been introduced by the Japanese.

Fig. 26. Preparing rice straw for a thatched roof in Korea

Causes of Low Yields

The lack of satisfactory irrigation systems, and hence a constant supply of water during the growing season, is one of the main factors contributing to the low acre-yields of rice in Korea. Dr. H. Hotta of the Suigen Experiment Stations, Suigen, Chosen, says that about two-thirds of the rice area has poorly developed irrigation systems or none at all, and are largely dependent for good crops upon a timely distribution of the rainfall during the months of July, August, and September. If the rainfall is low or poorly distributed during these months the acre-yields are reduced. The improvement of the irrigation systems is under way and at the end of 1922 about 850,000 acres were under controlled irrigation systems, or about 22 per cent of the rice area. As the irrigation systems are developed the acre-yields no doubt will be increased considerably. In sections where water is scarce pits are dug in the small paddies, and here the water collects in time of plenty. Then when the crops need it the water that remains in these pits is lifted on to the land by means of buckets, hand pumps, etc.

Production

The production, consumption, population, surplus, and per capita consumption of rice in Korea are given in Table 8.

Comparing the 5-year period ending in 1915 with the 3-year period ending in 1923 there was a 21 per cent increase in production; 6 per cent increase in consumption, 15 per cent increase in population, 128 per cent increase in the surplus, and a 9 per cent decrease in the per capita consumption. Production has increased considerably faster than the population and increase in consumption. The decreasing per capita consumption of rice in Korea is unusual and indicates either that the Korean people are poorer financially than they were, or that the demand for rice in Japan is so urgent that the Koreans are induced to do with less rice in order that it may be exported to Japan. Where rice is the staple food, however, the per capita consumption normally increases with increased production or increased wages, so here we have the exception to that rule.

The Japanese propose during the next 12 years to increase the area devoted to rice in Chosen by about 850,000 acres, according to Consul General Miller at Seoul. If these plans materalize it is expected that 1,500,000 short tons of rice will be available for export to Japan each year.

Table 8. Acreage, production, total consumption, per capita consumption, and surplus of rice in Korea, with the total population
1911-1926

Period	Acreage	Production	Consumption	Population	Per capita consumption	Surplus
	Acres	Koku	Koku		Pounds	Koku
1911-1915		12,303,983	10,797,063	15,310,038	233	1,506,920
1916-1920		14,101,115	11,729,260	17,022,611	227	2,371,855
1921-1923		14,837,763	11,403,750	17,654,881	213	3,434,013
1924	3,151,800	12,129,700	13,477,600 1/			
1925	3,885,000	14,277,927	14,275,500 1/			
1926*	3,777,000	14,920,727	14,902,400 1/			

* Provisional data.

1/ Changed bushels to pounds, deducted 20 per cent and divided by 330 pounds for koku.

Fig. 27. Carrying brown rice to the boat in Korea

Fertilizers

The Japanese are encouraging the use of artificial fertilizers as well as the natural fertilizers that are available and have been used since early times. Likewise they are encouraging the growth of green manure crops on the rice land, as well as other second crops such as wheat, barley, and vegetables. The more general use of fertilizers and green manure crops no doubt will help to increase the acre-yields of rice.

Varieties

Improved Japanese rice varieties have replaced largely the Korean varieties in the better developed rice areas of central and southern Korea, and to a smaller extent in other sections. Early maturing varieties are grown in the northern and northeastern provinces, midseason varieties in the central provinces, and largely late maturing varieties in the southern provinces. About 70 per cent of the rice area now is sown each year to improved Japanese and Korean rice varieties. The balance of the acreage is in native varieties some of which are better adapted to withstand alternate wet and dry periods, and cold temperatures than are the Japanese varieties. Most Korean rices are awned which reduces the damage by birds. At the Suigen Experiment Station a large collection of native and introduced rices are being tested in the nursery and plats. Rice in Korea is sown in the seed beds about May 1, transplanted from June 10 to 15 and is harvested from September 15 to October 30, and later.

The Korean varieties as a rule do not yield as well as they should on land that is fertilized. The native varieties produce but few stools with long panicles and lodge quite easily. These varieties have apparently been grown so long on wornout soils that the types that now exist are unable to adjust themselves to a more fertile soil. On the other hand the Japanese rices do not do so well on poor soils, but on well fertilized soils they stool freely and produce many panicles on relatively short stiff straw which results in high acre yields.

The Koreans do not transplant the rice in straight rows as they do in Japan. The rice fields and levees are not kept so free of weeds as they are in Japan. The rice is usually weeded twice after transplanting, but should be weeded three or four times. In some sections of low rainfall in northwestern Korea, according to N. Takahasi, the rice is sown on dry ground in the same manner as upland rice, but after the rice emerges, levees are built around the fields, and the rice is cultivated during the dry weather to conserve moisture. This is sort of a cross between lowland and upland methods and gives yields that are intermediate. The rice is harvested by hand and shocked on the levees. No drying racks are used though they are needed. The rice is threshed by flailing, treading out on threshing floors, etc. The quality of Korean rice is not as good as that of central and southern Japan.

Other Crops

Besides rice there are large areas devoted to other food crops. During the 5-year period ending in 1924 wheat was grown on 878,900 acres; barley on 2,128,000 acres; oats on 268,600 acres; maize on 227,200 acres; and potatoes on 185,800 acres. In 1917 there was 1,250,000 acres in soy and red beans and 1,750,000 acres in millets of various kinds. The yields of these crops are low; the average for the 5-year period ending in 1924 was wheat 11 bushels; barley 17 bushels, oats 18 bushels, and maize 13 bushels per acre.

Wheat, barley, and genge are grown quite extensively as second crops on rice land. Wheat and barley are also grown on upland that has produced summer crops such as soybeans, millet, corn, etc. Oxen and horses are used as draft animals.

Besides the Central Experiment Station at Suigen there are substations located in each province where varietal, fertilizer, and cultural experiments with various crops are being conducted.

CHINA

The total area of China proper is 1,896,500 (Manchuria 363,700) square miles. The total area including Mongolia, Chinese Turkestan, and Tibet is 4,278,352 square miles. It is estimated that one-fourth of the population of the world are Chinese, and probably 80 per cent of the people are engaged in agricultural pursuits.

China proper from an agricultural point of view may be divided into three main basins, according to the Chinese Year Book 1926.

In the north is the Hwangho or Yellow River Basin with an area of 600,000 square miles and a population of 100,000,000 people. This basin has a more severe climate, and the crops grown are different from those in central and southern China. The watershed dividing the Yellow and Yangtze River Basins is roughly the northern limit of rice culture, and wheat, millet, kaoliang and beans are the principal food crops grown in the Yellow River Basin and further north. There is, however, some rice consisting of upland and lowland types grown in favorable locations in this basin and in Manchuria. Oxen and camels are the main draught animals in north China.

In central China is the Yangtze Kiang Basin with an area of 600,000 square miles and a population of 180,000,000 people. This basin has a temperate climate and a fertile soil. The principal crops grown are rice, silk (mulberry trees), cotton, and tea. This is the most important agricultural section in China. It is well watered with a network of rivers, canals, creeks, ponds, etc. and is not subject to drought and serious floods like the Yellow River Basin.

Here rice is the principal crop, and wheat, barley, and legumes are often grown as second crops following rice on the irrigated lands. The water buffalo and ox are the main draft animals on the farms in central China.

In south China is the Li Kiang (West River) Basin with an area of 390,000 square miles and a population of 60,000,000 people. This basin has a tropical or semitropical climate, and crops occupy the tillable land at all times. Rice is also the main crop in this basin. In the Li Kiang Basin it is estimated that there are 150 persons per square mile; in Yangtze Basin 420; in the Yellow River Basin 160; and for all of China 200. Estimates place the cultivated area in the 22 provinces of China at about 180,000,000 acres or about one-half that of the United States. There are, I was told, good agricultural districts in the interior of China and in the north that are sparsely populated and undeveloped due to lack of communications.

In southern and central China rice is the staple food, but in north China wheat, millet, kaoliang, beans, and other crops have a more important place in the diet. There are, therefore, millions of Chinese in the north who do not use rice exclusively as the staple food, but even there those who can afford to eat rice.

Rice Production

In a normal year it is estimated that China produces from 25,000,000 to 30,000,000 short tons of cleaned rice which is more than that of any other country, except India. Yet the consumption of rice in China exceeds the production, and rice is imported in large quantities each year, largely from French Indo-China, Siam, and India.

The leading rice producing provinces in the order of their importance are: Kiangsu, Hunan, Hupeh, Anhwei, Kiangsi, Szechwan, Chekiang, Kwangtung, and Fukien.

Kiangsu and Hunan are covered by a network of rivers, streams, and canals which supply the necessary water for the rice crop, and the soil and climate are well suited for rice production. The first seven ~~provinces~~provinces listed above are reported to produce two-thirds of the total rice crop of China, the remainder being produced by Kwangtung, Fukien, and other provinces. Hunan, Anhwei, and Kiangsi grow more rice than is consumed, and the surplus is sent to other provinces.

The Chinese Year Book states that "The social value of wages is determined in the more industrial cities of China by the cost per picul of rice. When rice reaches as high as $13. to $15. (mex) per picul in Shanghai, there will be strikes, unless some measures are taken by employers to offset the difference between the normal cost of rice (say $8. to $10. mex) and the abnormal in relationship to the wages paid." This indicates the importance of rice in the diet of the working people.

Implements and Farm Animals and Land Preparation

The farm implements used in China are crude and consist of wooden plows, harrows, ~~and~~ iron spades, ~~like old~~ and prong hoes. Draft animals are more commonly used in the Yangtze Valley than in Japan. Most of the land is plowed when dry or moist, and the rice land is harrowed in the water as a final preparation before the rice is transplanted. There are no fences in China, but farms are marked off by stones.

In the Yangtze Valley the rice is grown on level land that appears to be well adapted for rice culture. The paddies are small and surrounded by low, narrow levees such as are used in Japan. The methods used in rice growing in China are essentially the same as those used in Japan. In the Yangtze Valley the sprouted rice is sown on well prepared seed beds during April, and the seedlings are pulled and transplanted in from 30 to 45 days after seeding. The seed beds are fertilized with natural manures, and the land is irrigated at night and drained during the day time. The rice is not transplanted in straight rows as in Japan. The distance between the rows and the space between the hills in the rows vary as they do in Japan and depend upon variety, climate, and fertility of the land. In the Yangtze Valley the rows are usually about 9 inches apart, and the hills consisting of three to five seedlings are spaced about 8 inches apart in the rows. In the southern provinces, I was told, the rows are usually spaced farther apart, and more seedlings are placed in the hills which are spaced about 10 to 12 inches apart.

Implements and Farm Animals and Land Preparation

The farm implements used in China are crude and consist of wooden plows, harrows, and iron spades like ~~old~~ prong hoes. Draft animals are more commonly used in the Yangtze Valley than in Japan. Most of the land is plowed when dry or moist, and the rice land is harrowed in the water as a final preparation before the rice is transplanted. There are no fences in China, but farms are marked off by stones.

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Fig. 28. Preparing a rice seedbed in China

By Mactavish & Co.

Varieties

There are many rice varieties in China including early, midseason, and late maturing varieties, and many of these lodge and shatter to such an extent that they are undesirable for use in countries that use binders in harvesting. The Chinese rice varieties have not been improved by pure-line selection, and many inferior varieties are still in use.

Mixtures are common, and red rice is found in many of the varieties. The importance of pure seed is not generally appreciated as it is in Japan. Varietal testing and pure-line selection work with rice has been started at the agricultural colleges and other agricultural schools in China, and if the improved varieties that are isolated by these methods can be placed in the hands of the growers marked increases in the acre-yields and quality of the crop should be obtained.

The breeding program should include, and no doubt will include, the selections of varieties that are resistant to diseases and those that are less inclined to lodge and shatter, for these are undesirable varietal characteristics even in countries where machinery is not used.

Mr. C. C. Yuen, of the National Southeastern University of Nanking, has compared the yields of pure-line rice selections and ordinary unselected rice and found that the selected rice gave yields about 23 per cent higher than that of the unselected. This indicates the vast good that would result from a general use of improved rice varieties. China grows common, glutinous, and upland rices, but most of the acreage is in common lowland rice.

Irrigation

The rice is irrigated from canals, ponds, and lagoons in which the water is a few feet (2-6) below the surface of the land. The irrigation water is raised from the canals, ponds, etc. by means of pumps operated by human power and by water buffalo. The pumps consist of an endless wooden chain with paddles attached running in a wooden trough through which the water is lifted to the rice paddies. These pumps are often operated by hand or by treading upon paddles in a manner similar to the old treadmills. When an ox or water buffalo is used for pumping they are hitched to a big circular bull-wheel directly connected to the shaft in the upper end of the trough. The animals travel in a circle and are protected from the sun by a shelter made of straw. In this respect these animals receive more consideration than do the humans who operate the pumps for they do not always have a shelter built over them.

On some of the land near Nanking which is rather uneven and not so well supplied with water small ponds are dug near the rice paddies to catch water during the wet season. Then when needed the water is pumped from these ponds, but the supply is often insufficient to properly mature the rice crops. There are also some sections along the Yangtze and its tributaries where water can be taken by canals from the river at high tide and used on the rice land, then drained off, if desired, at low tide. The depth of water held on the rice fields is less than we use in California. I was told that where drainage is good the rice fields were drained for a short time just before the panicles ~~heads~~ began to emerge.

Fig. 29. Lifting irrigation water for rice by hand power in China

By Mactavish & Co.

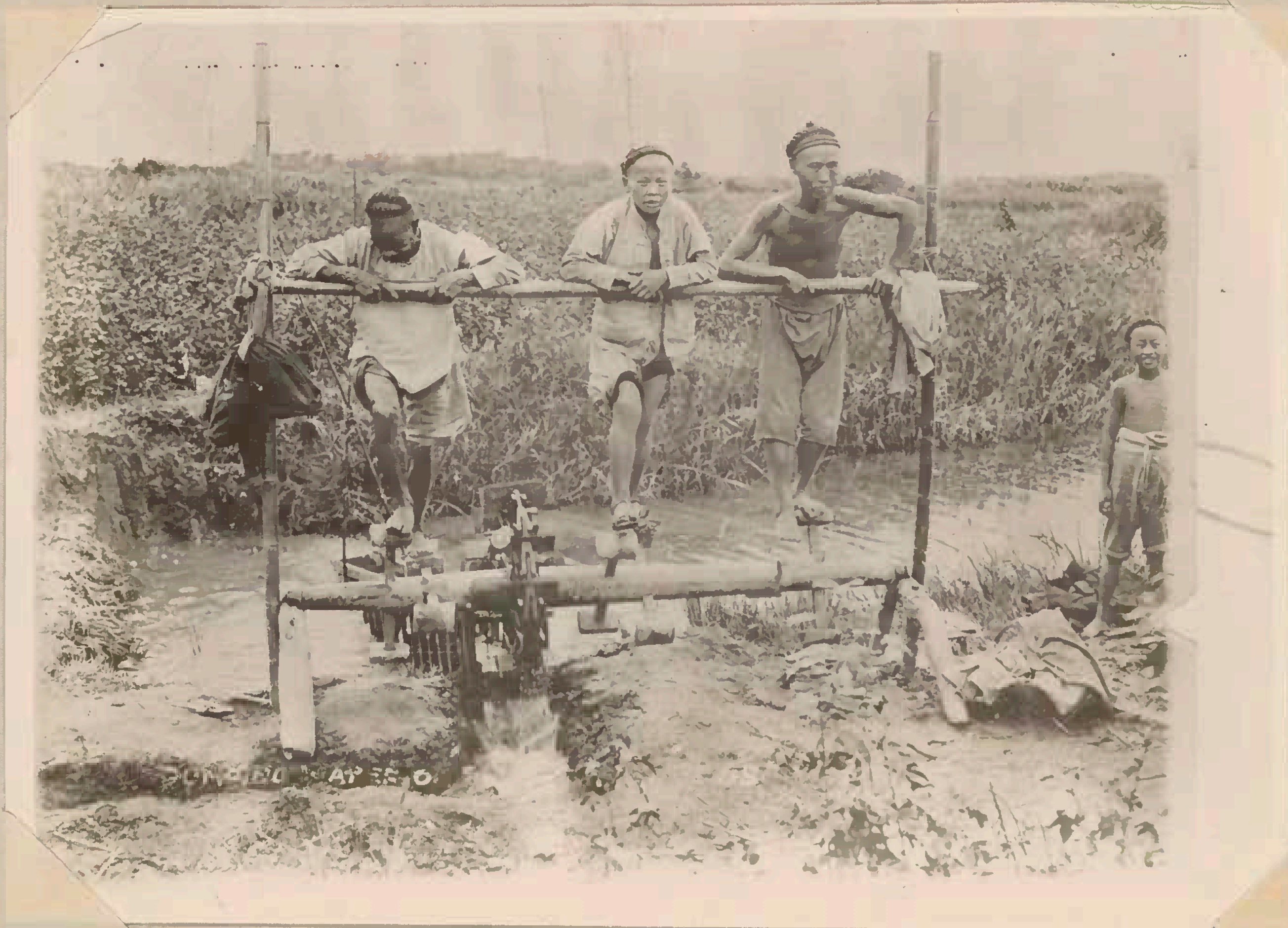

Fig. 29. Lifting irrigation water for rice by foot power in China

By Mactavish & Co.

Fertilizers

Rice has been grown in China since ancient times, and still the land is producing good crops. This is due to the fact that every available waste substance that possesses plant food elements is used as fertilizers. The uncropped land contributes to the fertility of the cropped land for vegetation is gathered from the hills, as well as from ponds and lakes for use as fertilizers. Night soil, farm manure, compost material, garbage, sediment from ponds, lakes and canals, street sweepings are all used to help maintain the fertility of the soil. In more recent years some bean cake and sesamum cake is being used, and green manure crops consisting of clover (genge) and soybeans have been used for many years. Commercial fertilizers are not yet in general use. The sediment from canals, ponds, and shallow lakes is usually gathered during the slack season in the fall and is liberally spread upon the land during the growth of the second crop, which may be barley, wheat, or legumes.

Mr. Goff says "The Chinese farmers could not name for you the essential plant foods, nitrogen, phosphorus, and potassium, but they know the valuable raw materials which contain these elements and which feed the plants, and they also know in what stage of the plants development each kind of food is needed. During the days of soil preparation and seed-sowing they are busily collecting and keeping under the most favorable conditions the raw materials that contain these elements."

The rice fields are systematically weeded and are practically free of weeds. Barnyard grass and sedges are common weeds in China, as they are in the California rice area, but by transplanting and hand weeding they are kept under control. As Mr. Goff says "The weed, that universal enemy of our American farmer, is seldom thought of in China; ages ago it was exterminated as a useless space consumer. The closest economy of sunlight and water is thus observed." (Agricultural Reciprocity between America and China. Bul. No. 5., By Geo. W. Goff)

Harvesting and Threshing

The rice harvest begins in the north and proceeds south - much as it does in Japan. In the Yangtze Valley September and October are the main harvest months. The rice is cut near the ground with a hand sickle and is dried in windrows. It may be threshed from the windrows as soon as dry, or stacked at the farmers house and threshed later. The wheelbarrow, donkey, water buffalo, man, and boat are used to transport the rice from the fields to the farm homes when it is stacked. There are two methods of threshing; the first consists of a box with flaring sides on which the rice panicles are beaten and the rice is collected in the box, or a slatted table may be used on which the rice is beaten and the paddy is collected on mats or the ground beneath the table; the second method consists of a threshing floor of hard clay or stone on which the rice is spread and then corrugated or smooth stone rollers are drawn over the rice by hand or by water buffalo. The rice is ~~(Agricultural Reciprocity between America and China. Bul. No. 5. By Geo. W. Goff)~~ cleaned by winnowing and is dried after threshing on straw mats exposed to the sun. The rice straw is used for fuel, food for the water buffaloes, thatching of mud huts, bedding, mats, compost material, etc. The rice not needed for home use is sold to Chinese rice mills, where the rough rice is dehulled and polished. Except in Japan, the Chinese dominate the rice milling industry in all Asiatic countries.

Fig. 30. Threshing rice in China

By Mactavish & Co.

Yields

The yields of rice in China are no doubt much higher than those obtained in other Asiatic countries with the exception of Japan. It is estimated that the yields range from 200 to 350 catties (1 1/3 pounds) per mow (about 1/6 of an acre) or from 1600 to 2800 pounds of rough rice per acre.

Piricularia causes some damage to the rice crop in China, and the stem borers likewise do considerable damage each year.

Farm Survey

In a farm survey of 102 farms near Wuku in Anhwei Province which is in a good rice area, Buck reports that 55 per cent of the farms were farmed by owners; 32 per cent by part owners, and 13 per cent by tenants. The average sizes of the farms of owners was about 3.5 acres, of part owners 6.3 acres (2.3 rented), and tenants 2.5 acres. Man labor and equipment were found to be twice as efficient and animal labor three times as efficient on the large as on the small farms. "The labor income of the owner was minus $15.00 (mex); of the part owner $156.; and of the tenants $105." Farm labor was the most important item in farm expenses - 71 per cent of the total. The interest rate in the Wuku district averages about 35 per cent. The average size of the families was 5.4 persons. Land was not profitable if valued at more than about $100 (mex) per mow. According to these studies the landlord earned only 2.5 per cent on his investment. All of the land grew a rice crop during the summer and 79 per cent of it was sown to second crops consisting of wheat, barley, and rape-seed. This indicates the extent to which the land is double cropped in this rice area. The barley and wheat are sown on land that is ridged

up to a certain extent to provide drainage as is done in Japan. The crop may be sown in rows or broadcast on the ridges - if in rows beans are often sown between the rows.

In one section I noticed a crop of adobe brick being taken from the land after the rice crop was removed. The stubble was cut off at the surface of the ground, and the soil was cut into rectangular brick-like blocks which were raised from the ground and placed on the levees to dry. Many of these adobe brick piles were seen north of Soochow.

Near the large cities a great deal of land is devoted to grave mounds on which some grass is grown. Reeds from the lowland along the Yangtze River are cut and hauled to the cities on donkeys or wheel-barrows and sold for fuel. The mountains in eastern China are baren and unattractive like those in southern Korea. (An Economic and Social Survey of 102 Farms near Wuku, Anhwei, China. By J. L. Buck. University of Nanking. Agriculture and Forestry Series Vol. 1, No. 7. 1923.)

Fig. 31. A common drayage outfit in Shanghai, China

Mactavish & Co.

Fig. 32. A road crusher at work in China

Mactavish & Co.

JAVA

The archipelago comprising the Dutch East Indies covers an area of 733,681 square miles. The population in 1920 was 49,351,000. Of the total population about 36,000,000 are on the islands of Java and Madura. The total area of Java and Madura is 50,752 square miles or a little larger than the State of New York. There are over 690 people per square mile on these two islands, but in Sumatra, Borneo, Celebes, etc. there are only about 25 persons to the square mile. About 70 per cent of all the people in Java who have an occupation are engaged in agricultural pursuits.

The islands of the Dutch East Indies are mountainous, and the soil is of volcanic origin. In Java the soil is more fertile than in the outer districts (Sumatra, Borneo, Celebes, etc.) and for this reason practically every foot of available land is under cultivation. The climate is favorable for crop production, and in no other tropical country is such a large variety of produce grown as in the Dutch East Indies and especially Java. Agriculture is the most important industry, and through encouragement by the Government, it is conducted on a scientific and intensive basis. Two types of agriculture are present in the Dutch East Indies, the so-called large agriculture and the native agriculture. The former is termed a capitalistic industry and produces crops primarily for export purposes, while the native agriculture, especially in Java, is concerned largely in the production of crops to supply the needs of the native population.

In Java practically all of the lowland and the mountain land up to an elevation of nearly 5,000 feet is cultivated. Above this elevation the mountains are covered with natural forests. The products grown at the higher elevations include cinchona, tea, coffee, and vegetables; in the hill districts at a lower elevation the crops grown are corn, cassava, peanuts, and tobacco, and on European estates tea, coffee, and rubber are produced. Irrigated rice on terraced land also is grown commonly in the hill districts, and natives can successfully terrace land with a slope of 45 degrees. On the alluvial lowlands rice is grown extensively, as well as sugar-cane, corn, cassava, sweet potatoes, peanuts, soybeans, cocoanuts, tobacco, kapok, fruits, vegetables, etc.

Rice

Rice is the most important crop grown by the native farmers, and it is the staple food of the native population. Both irrigated and nonirrigated (upland) rices are grown in Java. Most of the rice, however, is grown on irrigated land.

Seed Beds

The methods used in rice culture in Java are quite similar to those in Japan. The irrigated rice is sown first in seed beds where it is grown from 30 to 50 days before it is pulled and transplanted in the fields. The seed beds are well prepared and consist of three kinds, dry, semi-wet, and wet. In the dry seed beds the seedlings are grown with very little water. In the semi-wet seed beds the rice is sprouted and sown broadcast, and the land is kept wet by irrigation, but not submerged. In the wet seed beds the land is submerged part of the time as is done in Japan. I was told that floating seed beds are sometimes used in swampy sections. The floating seed bed consists of broad leaves on which some straw and a thin layer of soil is placed. The rice is sown on the soil, and the leaves float on the water until the seedlings are ready for transplanting. The dry and semi-wet seed beds are used most commonly in Java. The seedlings on these seed beds often turn quite yellow and look rather unhealthy, but I was told that such seedlings result in plants that are as productive, or more productive than seedlings that retain a deep green color and make a larger growth in the seed beds. The tops of the seedlings are cut off before transplanting. This tends to reduce the amount of water transpired by the leaves until the seedlings become established after transplanting.

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Seed Beds

The methods used in rice culture in Java are quite similar to those in Japan. The irrigated rice is sown first in seed beds where it is grown from 30 to 60 days before it is pulled and transplanted in the fields. The seed beds are well prepared and consist of three kinds, dry, semi-wet, and wet. In the dry seed beds the seedlings are grown with very little water. In the semi-wet seed beds the rice is sprouted and sown broadcast, and the land is kept wet by irrigation, but not submerged. In the wet seed beds the land is submerged part of the time as is done in Japan. I was told that floating seed beds are sometimes used in swampy sections. The floating seed bed consists of broad leaves on which some straw and a thin layer of soil is placed. The rice is sown on the soil, and the leaves float on the water until the seedlings are ready for transplanting. The dry and semi-wet seed beds are used most commonly in Java. The seedlings on these seed beds often turn quite yellow and look rather unhealthy, but I was told that such seedlings result in plants that are as productive, or more productive than seedlings that retain a deep green color and make a larger growth in the seed beds. The tops of the seedlings are cut off before transplanting. This tends to reduce the amount of water transpired by the leaves until the seedlings become established after transplanting.

Transplanting

The seedlings are transplanted in rows from 10 to 12 inches apart, and the hills are spaced from 8 to 10 inches apart in the rows. The number of seedlings per hill varies from two to five depending upon the variety of rice used. Early maturing varieties are sown thicker than late maturing varieties - more seedlings per hill. The rice is not transplanted in straight rows as in Japan.

The climate in Java is such that rice can be and is grown, where water is available, during the entire year. One sees in the same section farmers preparing and sowing the seed beds, preparing the land for transplanting and transplanting, rice in all stages of development, and rice being harvested. Most of the rice, however, is sown from November to January, in the wet season, and it is harvested from May to August, in the dry season. On part of the land two crops of rice are grown each year, and in other sections three rice crops are grown in two years. Where water is not available for a second rice crop during the dry season, the land is often sown to corn, cassava, sweet potatoes, peanuts, soybeans, cotton, and tobacco.

Land Preparation

The land is well prepared before the seedlings are transplanted. On the lowlands water buffaloes or native bullocks are used in preparing the land, but on some of the terraced fields the land is prepared by hand. The implements used are light and rather crude, but field work is continued until the land is prepared well. Teams of water buffaloes and bullocks, rather than a single animal as in Japan and China, are used in Java for plowing and harrowing the land. The land may be plowed, dry, wet, or in the water. It often is plowed more than once, and the final preparation of all the irrigated rice land is to plow and harrow it in the water until the surface of the soil is reduced to a thick soup-like consistency. Large weeds and other growth often are cut with a hoe (pajoel) and removed from the land before plowing begins. In some sections the water buffaloes mire down almost to their stomachs in mud and water, while in other places these animals only sink in a few inches. The land is well prepared before transplanting, and this is possible where labor is plentiful and cheap. In fact there are so many laborers present on land that is under preparation that it appears to one unaccustomed to hand labor that the people are collecting for some party or celebration.

Varieties

There are many rice varieties in Java. Mr. L. Koch of the Department of Agriculture at Buitenzorg, informed me that they had collected 1500 varieties, and he felt that 1500 more could be easily collected. The rice varieties based on maturity are classed as early, midseason, and late. The early varieties require from 140 to 155 days from seeding to maturity, the midseason varieties from 155 to 170 days, and the late varieties more than 170 days. Common and glutinous (Ketan) rices are grown, but much less glutinous than common ~~rice~~. There are awned and awnless varieties and both kinds are extensively grown.

In temperate climates rice is self-fertilized normally, but a small amount of cross-fertilization is not uncommon. In India results indicate that there is from 4-6 per cent of cross-pollination; in Japan results indicate from .15 to 3 per cent of natural crossing, and in California there is practically no cross-fertilization. In Java, on the other hand, the lowland (irrigated) rice varieties are, with respect to the method of pollination, placed in three groups: "1. Varieties with open pollination (chasmogamy); 2. Varieties with variable pollination subject to climatological factors; 3. Varieties with closed pollination (cleistogamy).

It is probable that by far the largest part of the rice varieties of the Netherlands, Indies belong to the second group. In dry, sunny weather they show generally autofecundation; with cloudy, moist weather, cross-pollination."

Bloembiologische onderzoekingen betreffende sawahrijst.

By F.F.R. H~~g~~oide. 1923.

Selection

The pure-line selection work with rice conducted by the Department of Agriculture at Buitenzorg and elsewhere in Java, has not met with the marked success that has been reported in other rice producing countries. In fact the results have been quite disappointing. There are three reasons given as to why the pure strains have not ~~given~~ produced the results expected of them. (1) The climatic conditions vary a great deal from year to year and in unfavorable season the yields of pure strains are low and in favorable seasons high, on the other hand, mixed strains are more constant in yield under variable conditions; (2) rice is grown on various soil types especially in the coastal regions, and pure strains lack adaptability when grown on various soil types; and (3) the large amount of natural crossing makes it difficult to isolate, maintain, and test pure-line selections. All rice growing countries have variable climatic conditions from year to year and usually different soil types on which rice is grown, and yet in most countries for which I have seen data they have obtained increased yields by the use of pure-line selections. Of course in countries with various soil and climatic conditions a number of pure-line strains would no doubt be needed, each adapted to the conditions under which it is grown. The Dutch report that pure strains are not adaptable, and for this reason they often are disappointing when grown under conditions differing from those in which they were isolated. They ~~found~~ find that a suitable mixture of pure strains is more plastic and usually gives higher yields than individual selections. Not all strains, however, can be mixed to advantage.

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Mr. Koch of the Experiment Station at Buitenzorg now bags the rice panicles for several years when pure seed is desired. Due to the fact that natural crossing is so common, the rice crop is now being subjected to the same methods of improvement as are used on naturally cross-fertilized crops - like corn. It will be interesting to see what the results of such improvement work will be, and I hope that their labor will be rewarded for the Dutch have been leaders in rice investigations and to date have been rather disappointed in the results of their rice improvement work.

The rice countries with tropical and semi-tropical climates offer excellent opportunities for genetic studies with rice. At least two, and if short season varieties were grown, three generations can be grown in a year. While in the temperate rice countries under field conditions only one generation can be grown.

The tropical rice varieties in Java grow much taller than do the short-grained varieties in Japan, and the Japanese varieties grow still shorter in tropical Java. For example, I saw the Japanese varieties Aikoku, Shinriki, Omachi, and Miyako growing in plats at the Experiment Station at Buitenzorg. All four varieties had been transplanted for about 60 days - so the plants were probably 95-100 days old - and were practically fully headed. The plants were about 18 to 20 inches in height, and the panicles did not appear to exceed 4 inches in length. In other words, these varieties were not suited for growth in Java, but in Japan they are extensively grown and yield well. In Japan, I was told that the Japanese had succeeded after many years of trial in

adapting their varieties to conditions in Formosa, which has a semi-tropical climate. But as a rule tropical and semi-tropical rice varieties are not suited for growth in temperate climates and vice versa. The Javanese rices usually grow to a height of from 4 to 5 feet, and as a rule the awned varieties stool less than the awnless varieties, but the awned varieties do not shatter as readily as the awnless and for this reason often are grown when the crop has to be transported for any distance in the panicle.

Ratoon Crops

Rice in Java will grow one or more years from the old rice roots (ratoon crops), and this often results in mixtures on poorly prepared lands. Rice when propagated vegetatively for three or more years becomes unhealthy in color and lacking in vigor. The plants deteriorate probably due to diseases. The fact that the rice plants can be increased vegetatively, however, makes it very easy to obtain a relatively large supply of seed from a desirable plant or strain.

Irrigation

Rice is the most important crop under irrigation in Java. The natives have had irrigation systems for the raising of rice since early times. It is estimated that 71 per cent of all land tilled by the native farmers is devoted to rice. The irrigated rice fields vary in size from a few square yards in the terraced lands to an acre or more on the plains. The rice paddies are surrounded by low narrow levees and only shallow water, 2-4 centimeters, is held on the fields, and this is kept quite fresh by a constant intake and outgo of water. The young rice seedlings are injured easily by the irrigation water if it is not kept fresh by circulation, or if it is held too deep. The continuous submergence method of irrigation, such as is being used in California for the control of barnyard grass, would be fatal to the young rice plants in Java, because there the heat soon drives the oxygen out of the water and scums develop quickly.

In Java [1/] the rice requires about .41 of a pound of water per

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1/ Handbook of Dutch East Indies. 1924.

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second for each acre during the wet season to take care of transpiration and evaporation, and, while seepage varies on different soil types and in different districts, a water supply of from 1 to 1.25 pounds per second per acre during the entire irrigation season is reported to be sufficient on the plains.

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Terraced Rice

In the mountain districts there is a great deal of terraced land on which irrigated rice is grown. The terraced paddies are small and as a rule are much less productive than lowland. The water passing from a higher to a lower check often falls from 10 to 15 feet. It is quite an interesting sight to see these numerous little water falls in the terraced rice area. It requires an enormous amount of labor to convert a hillside into terraced paddies, but in Java there is a surplus of labor and a shortage of land for cultivation.

Upland Rice

The upland or non-irrigated rice is sown directly in rows, usually in hills rather than in continuous rows. The upland rice is weeded and cared for just like other crops that are grown in rows. A great deal of upland rice was seen growing between rows of corn and cocoanuts in the hill districts. Parts of forests are sometimes destroyed for the purpose of planting an upland rice crop. The land in such cases does not receive cultivation, and the rice is sown in hills. The land may be abandoned after growing one or more crops due to washing etc. This method is quite common in the outer districts.

Fertilizers

Fertilizers are not used commonly in Java on the rice lands. Part of the rice crop, however, is grown in rotation with sugar-cane, and it probably gets some benefit from the fertilizers that are used on the cane crop. The irrigation water in Java carries a great deal of sediment and plant food elements in solution, and this material helps to maintain yields on the irrigated fields. The soil, being of volcanic origin, is deficient in lime, and the heavy rainfall during the wet season (west monsoon) leaches out the nitrogen. Rice in the fertilizer plats at Buitenzorg Station both non-irrigated and irrigated, indicated that nitrogenous fertilizers could be used to advantage, for on the plats that had received applications of ammonium sulphate the rice showed a marked improvement in growth in comparison with the growth on unfertilized plats. Then too, I was told that rice following leguminous green manure crops on either upland or irrigated land shows a marked improvement in yields. The following crops add a large amount of nitrogen when used as green manure crops. Crotalaria anagyroides, Mimosa invisa, Phaseolus semierectus, Crotolaria usaramoensis, and Indigofera sumatrana. They are easily grown in Java and materially enrich the soil in nitrogen and humus.

On the Experiment Station at Buitenzorg it is necessary to remove as much sediment as possible from the water before it is applied to the plats. If the water is applied directly the rice on the plats nearest the intake often grows so rank that it lodges and fails to mature. The water is held in checks, therefore, for some time before it is admitted to the experimental plats where comparative yields are being studied.

Weeding

The rice fields in Java usually are hand weeded twice after transplanting and are kept comparatively free of weeds. The weeds in the rice fields, however, are not kept under control as well in Java as they are in Japan.

Experimental results on the Experiment Station at Buitenzorg with direct seeding indicate that with good care the yields from direct seeding are about the same as from transplanted rice. When rice is sown direct, however, it must be weeded five times, while the transplanted rice is only weeded twice. At Buitenzorg small hand rice weeders are being tested, and they find that the rice sown directly can be weeded five times by women using these hand weeders cheaper than the transplanted rice can be weeded twice by men without machines, which is the common method of weeding.

Damage to Crop by Various Causes

The damage done to the rice crop in Java each year by diseases, insects, animal pests, floods and drought amounts to about 4 per cent of the area sown, while in the United States the reduction in the yields of rough rice for similar reasons ranges from 15 to 25 per cent. Adverse climatic conditions causes the largest reductions in yield in the United States.

Harvesting

Rice in Java is harvested by hand by men, women and children, but instead of cutting a hill at a time as they do in Japan, each panicle so to speak is harvested separately. The harvested panicles have about 8-12 inches of straw attached and are tied in small bunches, and a number of these small bunches are tied together until a bundle is obtained with an average weight of 10 catties or about 13 pounds. The unthreshed paddy with straw attached is sold to the rice mills. It may be shipped to the mills by rail or brought in on carts or on the shoulder poles which are used so extensively in the Orient. The rice mills have large drying floors made of cement, tile, or brick, and after the bunches of rice are thoroughly sun dried on these floors they are stored in warehouses in piles ranging from 10-25 feet high and from 20 to 40 feet wide. All awned rices are piled together regardless of the shape and size of the grain, and likewise all awnless rices are placed in a pile regardless of size or kernel shape. Common and glutinous rices, however, are kept in separate piles. The rice keeps very well in these warehouses.

It appears, however, to take up considerable moisture in storage, for it is dried again on the drying floor before being threshed. From the threshers the rice passes directly to the cleaning machinery and from the cleaners to the hulling stones, and from there to the polishing machinery, and finally the milled rice is placed in bags that hold about 220 pounds. The milled product shows a great deal of red rice. The natives, however, have no objections to red rice, and in fact they like

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Yields

The rice fields in Java, as stated before, are not fertilized as a rule, and due to the large amount of natural crossing that occurs and the fact that pure strains are not grown extensively, the fields are not so uniform in appearance as they are in Japan. But since the rice is harvested one panicle at a time and only the ripe panicles are cut a slight difference in the dates of maturity in a mixed population is not objectionable, in fact the Dutch have found that a suitable mixed population is often more productive than are selected strains. The average yield of the irrigated rice in Java and Madura for the 5-year period 1920-1924, inclusive, was about 1,625 pounds of rough rice per acre, or about one-half as much as is produced in Japan and slightly less than the average yield in the United States for the same period - 1,750 pounds per acre. The yields per acre for non-irrigated rice are slightly more than ~~one~~-half that of the irrigated rice.

The total acreage and production of cleaned rice in Java and Madura, from the 5-year period 1920-1925, is given in Table 9. The data in Table 9 shows that the total production remains about the same with some variations from year to year due no doubt to favorable or unfavorable climatic conditions.

Table 9. Acreage and production of cleaned rice in Java and Madura for the years 1920 to 1926, inclusive

Years	Acres		Yield of cleaned rice (1000 pounds)	
	Irrigated	Non-irrigated	Irrigated	Non-irrigated
1920-21	6,835,000	1,129,000	7,716,400	631,024
1921-22	6,472,000	751,000	6,942,768	418,133
1922-23	7,319,000	859,000	6,864,235	415,616
1923-24	7,287,000	879,000	6,831,953	425,080
1924	7,403,000	955,000	7,076,171	499,000
1925	8,234,000*	-	7,322,393*	-
1926	8,461,000*	-	8,251,428*	-

* Irrigated and non-irrigated.

Cost of Production

Table 10 [1] gives the cost of labor used in growing 1 hectare (2.47 acres) of rice by the native methods and by changed methods in Java. The cost of cutting and threshing is for 100 kilograms of rough rice with short and long straw or 176 pounds of rough rice.

[1] L. Koch. Vereenvoudigde Natte Rijstbouw. Dept. Landb., Nijv. en Handel [Dutch East Indies]. Meded. Alg. Proefsta. Landb. No. 21, 65 p. 1926.

If we assume that the average yield per hectare for lowland rice is 4,347 pounds of rough rice (1,760 pounds per acre) then by multiplying the cost of cutting and threshing 100 kilograms of rough rice by 24.7 we get the cost per hectare by the native methods or ƒ32.85 or $13.14 and by the changed methods ƒ33.84 or $13.54. Then the labor cost of producing 1 hectare of rice, which yields 4,347 pounds of rough rice, by the native methods is ƒ154.13 or $61.65. On an acre basis the cost is $24.96 or $1.42 per hundred. The labor cost of producing 1 hectare with the same yield by the changed methods, using the katjip in weeding, is ƒ95.10 or $38.04, and by using kembar for weeding, the cost is ƒ86.35 or $34.54. On an acre basis the cost by the changed methods when the katjip is used, is $15.40 or 87½ cents per hundred, and when the kembar is used, the cost is $13.98 or 79½ cents per hundred. It should be remembered that these costs are for labor only and do not include the cost of seed, water, sacks, land rental, etc.

Cost of Production

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Table 10.

Average quantity of work and money [1] spent on rice growing per H.A.

Native Methods

Twice plowing by wooden plows. Twice harrowing: 180.4 hours cattle work	F81.18	$32.47
Sowing rice on a seed bed after transplanting same: 105.9 men - hours	6.05	2.42
456.3 women - hours	16.20	6.48
9.4 hours cattle work	4.23	1.69
	26.48	10.59
Weeding two times by hand and feet: 381.6 women - hours	13.62	5.45
Harvesting per 100 K.G. rice seed: Cutting with a rice knife and drying the ears with short straw: 2.74 men - hours	.16	.064
26.18 women - hours	.93	.372
Threshing with a bamboostick	.24	.532
	1.33	.968

Changed Methods

Twice plowing by iron plows Twice harrowing: 86.1 hours cattle work	ƒ38.74	$15.50
Sowing the rice on the field: 2.55 men - hours	.15	.06
72.2 women - hours	2.61	1.044
7.9 children - hours	.20	.08
Replanting: 71.7 women- hours	2.56	1.024
	5.52	2.21
Weeding five times with a katjip: 476.3 women - hours	17.00	6.80
Weeding five times with a landak kembar: 144.4 men - hours	8.25	3. *
Harvesting per 100 K.G. rice seed: Cutting with a sickle: 6.35 men - hours	.36	.144
Gathering: 0.57 men - hours	.03	.120
3.35 women - hours	.12	.048
0.31 children - hours	.01	.004
Threshing the ears with long straw with a flail (men) and a bamboostick (women) 14.14 men - hours	.81	.324
1.12 women - hours	.04	.016
	1.37	.55

1/ People were paid at the rate of F 0.40 (16 cents) (men), F 0.25 (10 cents) (women) and F 0.175 (.07 cents) (children) per day of 7 hours. Labor by one man with one pair of oxen was charged at a rate of F 0.45 (18 cents per hour)

* Part of original manuscript torn off on which this figure was written.

F = 40 cents.

The katjip and kembar are hand weeders that are used between the rows of rice. Direct seeding and the use of these hand weeders materially reduce the cost of production, in fact the labor costs are reduced almost half. Cheap labor makes the cost of rice production per 100 pounds in Java much less than in California where machinery and high priced labor are used.

Seed Storage

In the tropical and semi-tropical countries seeds lose their vitality very quickly due to the heat and humidity. The experiment station officials at Buitenzorg are using now ordinary 5-gallon kerosene cans for the storage of seeds. The seeds are dried and placed in the warm, dry cans, and the cans are sealed immediately with paraffin wax. In these sealed cans the seed keeps in excellent condition, for it is protected against insects as well as the weather. These cans also are being used in the Philippine Islands for the storage of seeds.

Imports

There is little opportunity of extending the irrigated rice area in Java, and little hope, therefore, that Java ever will be able to grow sufficient rice for home consumption, without reducing the acreage in cash crops, for there is a considerable increase in the population from year to year. Under normal conditions the per capita consumption of rice in Java is 220 pounds of which about one-tenth is imported. The imported rice is obtained largely from Siam, French Indo-China, and British India. The rice imports to the Dutch East Indies for the past few years were as follows: in 1920, 115,350 tons; in 1921, 834,189 tons; in 1922, 686,750 tons, and in 1923, 348,904 tons.

Other Food Crops

Besides rice there are a number of other very important food crops grown by the native farmers. Of these maize, which is grown only by native farmers, ranks next to rice, followed by cassava, sweet potatoes, peanuts, and soybeans, all of which are important food crops of the native farmers and the native population.

The acreage and production of these crops in Java and Madura in 1923 was as follows: 1/

	Acres	Production in tons
Maize	4,027,882	1,267,300
Cassava	1,837,209	5,478,300
Sweet potatoes	435,165	1,063,100
Peanuts	458,650	134,300
Soybeans	409,594	96,600

1/ Facts and figures about the Neth. East Indies. 1924

It is interesting to note here that cassava and sweet potatoes are much more productive per acre than are corn and rice. The high percentage of albumen in soybeans makes this crop an important food for the native population, and in 1922 about 115,000 tons of soybeans were imported.

PHILIPPINE ISLANDS

The Philippine Islands occupy an area of 114,400 square miles. The estimated population in 1924 was 11,633,000 - or about 102 persons per square mile. The islands, therefore, are not populated densely like Japan, China, and Java. In 1924 about 12.5 per cent of the total area was under cultivation, or 9,170,399 acres. Of this cultivated area rice was grown on 4,292,638 acres, or 47 per cent of the total. Rice is by far the most important crop grown on the islands.

Size of Farms

The farms are small as in other Asiatic countries. In 1918 1/ the average size of the cultivated farms was 3 acres and of the cultivated and uncultivated farms $5\frac{3}{4}$ acres. In 1918 about 78 per cent of the 1,955,276 farms were operated by the owners; 13 per cent were farmed by share tenants, and the remainder by cash and labor tenants, etc.

1/ Statistical Bulletin of the Philippine Islands. 1924.

Climate

The tropical and semi-tropical climate in the Philippines is favorable for the production of a variety of crops. At Manila the mean maximum temperature is about 89 degrees F. and the mean minimum temperature 72 degrees. F. The rainfall is variable in quantity, ranging from 80 to 100 inches and comes largely during the growing season from May to December.

Some of the valleys are quite large and have sufficient slope to be drained well. The table-lands and plains are quite fertile, but crop yields often are reduced due to drought. In some provinces there are rather distinct wet and dry seasons, while in others the rainfall is distributed more evenly throughout the year.

Rice

Rice is grown in nearly all of the provinces of the Philippines, but the center of production is on the island of Luzon. The principal rice producing provinces on the island of Luzon are Bulacan, Tarlac, Union, Zambales, Nueva Ecija, Pampanga, Pangasinan, and Ilocos Sur.

Methods of Production

The methods used in rice growing in the Philippines are similar to those used in Japan. Approximately three-fourths of the rice area is devoted to transplanted lowland rice. Four methods of seeding are used. The usual practice for lowland rice is to sow in May the sprouted seed on a well prepared seed bed where the seedlings are grown from 30 to 45 days. The seed beds are kept wet, but not submerged. Dry seed beds are used to a limited extent in Pangasinan Province. Where water is available a second rice crop often is grown during the dry season. Early maturing varieties are used for the dry season crop in order that it will mature before the rainy season begins. The second crop, according to Camus, often is sown broadcast. Upland rice usually is sown in a plow furrow by hand, and the seed is covered with a harrow. Upland rice also is grown on patches of cleared forest or underbrush land. In this case the land is not plowed, but the rice is sown in holes that are made to receive the seed at the beginning of the rainy season. These cleared areas are used for rice for one or two years, and sometimes rice and corn are sown together in alternate rows. In about three years the cleared areas are abandoned, and other areas are prepared. This method is not commonly used at present.

Land Preparation

The Filipino rice farmers apparently do not prepare their rice lands nearly so well as they do in Japan, China, and Java. The land is plowed with water buffaloes, but the work is not done thoroughly. The paddies are as a rule small, and the dikes often are covered with grass and weeds. Weeds also are seen more commonly in the rice fields in the Philippines than in China, Japan, or Java. The rice fields where water is available are submerged from 1½ to 2 inches deep, and on heavy soils about 4 acre feet of water are required to produce a crop of rice.

Varieties

There are numerous rice varieties in the islands and the experimental results of the Bureau of Agriculture and the College of Agriculture indicate that many of these varieties are inferior and should be discarded in favor of the more productive ones. Many of the rice varieties grown by the farmer were observed to lodge very badly. Green manure crops and artificial fertilizers are not used commonly in the rice fields.

Fig. 33. Plowing a rice field near Manila, P.I.

Fig. 34. Plowing a rice field in Philippine Islands

Harvesting

The rice crop is harvested largely in December during the dry season. Men, women, and children harvest the rice by hand. The bearded varieties are harvested by cutting off the panicles one or two at a time with a few inches of straw attached as in Java. The bearded rice is tied in small bunches, and after drying it is handed to the rice mills on carts drawn by water buffaloes. In the mills the bunches of paddy rice are stacked in the warehouses as in Java. The most common method of harvesting, however, is to cut the rice with a grass hook about half way between the ground and the panicles. The cut rice is tied in bunches and allowed to dry for a time on the fields. Then the rice is shocked on the levees, and after harvest when well dried the bundles are taken to the stack-yard, and the rice is placed in small stacks most of which are round like oat stacks in the States. Later when there is little danger of rain the rice is threshed. Part of the rice no doubt is threshed without stacking by the small farmers.

Fig. 35. Harvesting rice in the Philippine Islands

Cost of Production

The following table, taken from Bulletin No. 37 of the Bureau of Agriculture, by J. Camus, gives the estimated cost of producing lowland and upland rice in the Philippines in 1920. There is roughly 2.5 acres in 1 hectare (2.47 acres), and the last column shows the cost per acre on the basis of 2.5 acres per hectare. Cheap labor in the Philippines makes it possible to produce rice at a much lower cost per hundred, even though the yields are low, than in California where machinery is used. The only operation that is more expensive in the Philippines than in California is transplanting compared with drilling and broadcasting. Yet transplanting is relatively inexpensive considering the amount of labor involved. The cost of harvesting and threshing is much cheaper than in California where machinery is used. On the basis of these figures regarding the cost of rice production it appears that the cost of and use of modern machinery in the islands certainly would not be justified.

(Rice in the Philippines, Bu. of Agri. Bul. No. 37, 1921)

Table 11.

The estimated cost of production of lowland and upland rice per hectare (2.47 acres) in the Philippines in 1920

Lowland

		Cost per Hectare	Cost per Acre
Preparation of seed bed, about 1/10 acre	1 m-d 1 a-d	$0.75	$0.30
Seed, about 96 pounds		2.50	1.00
Cleaning and fixing dikes	1 m-d	.40	.16
Plowing 1 hectare (2.47 acres) of land	7 m-d 7 a-d	5.25	2.10
Harrowing with "suyrd"	4 m-d 4 a-d	3.00	1.20
Lifting and distributing seedlings	2 m-d	.80	.32
Transplanting	14 w-d	4.20	1.68
Care of crop: irrigating, weeding, etc.	5 m-d	2.00	.80
Harvesting with "lingeao" (grass hook)	10 m-d	4.00	1.60
Stocking and hauling sheaves	2 m-d	.80	.32
Threshing with pioca and winnowing	5 m-d	2.00	.80
Rental of land		10.00	4.00
Cost of 32 gunny sacks at 20 cents each		6.40	2.56
Total		$42.10	$16.84
Cost per cavan (96 pounds) of paddy produced		$1.31	

* Estimated yield 32 cavans per hectare or about 1,229 pounds of paddy rice per acre. Cost $1.37 per 100 pounds.

Upland

		Cost per Hectare	Cost per Acre
First plowing	7 m-d 7 a-d	$ 5.25	$2.10
Second plowing	5 m-d 5 a-d	3.75	1.50
Harrowing	2 m-d 2 a-d	1.50	.60
Seed rice, 35 gontas (123 pounds)		3.50	1.40
Planting	1 m-d	.40	.16
Weeding	8 m-d	3.20	1.28
Harvesting with "Gatah" (Hand knife)	16 w-d	4.80	1.92
Threshing and winnowing	3 m-d	1.20	.48
Rental of land		5.00	2.00
Cost of 20 gunny sacks at 20 cents each		4.00	1.60
Total		$32.60	$13.04
Cost per cavan (96 pounds) of paddy produced		$1.63	

*Estimated yield 20 cavans per hectare or about 768 pounds of paddy rice per acre. Cost about $1.70 per 100 pounds.

m-d = man day, w-d = woman day, a-d = animal day.

Threshing

Some of the rice is threshed with modern threshers, but most of the crop still is threshed by driving animals in a circle over the grain on a hard threshing floor, by treading on the grain with bare feet, and by flailing, etc. The modern threshers break a great deal of the rice, but there is very little breakage when it is threshed by stock or by treading and flailing. In the rice mills some of the bearded varieties that are hard to thresh are run through two modern threshers placed one behind the other. The beardless varieties as a rule are easy to thresh, and some of them shatter quite readily.

In Table 12 is given the acreage, total production, and yield per acre in rough rice for the 5-year period from 1920 to 1924, inclusive, in the Philippine Islands. The yields per acre vary from 917 pounds in 1924 to 1,001 pounds in 1922 and 1923. The acre yields are, therefore, only about one-third as much as is produced in Japan, only slightly more than half as much as is produced on irrigated land in Java, and much less than the average yields obtained in the Southern States.

A more dependable supply of irrigation water would aid materially in increasing the acre yields of rice in the islands. In countries, however, that are visited commonly by typhoons it is difficult to develop and maintain irrigation systems.

Table 12. Acreage, total production, and yield of rough rice per acre in the Philippine Islands for the 5-year period from 1920 to 1925, inclusive 1/

Year 2/	Acres	Total production pounds	Yield per acre pounds
		(1000)	
1920	3,197,691	3,438,125	937
1921	4,133,251	3,923,869	949
1922	4,103,732	4,109,125	1001
1923	4,139,399	4,142,582	1001
1924	4,292,638	3,932,588	917
1925	4,265,000	2,814,199	660

1/ Data from Bureau of Commerce and Industry, Statistical Bulletin of Philippine Islands.1924.

2/ Year ending June 30th.

Fig. 36. Hauling bearded rice to the warehouse for storage and threshing in the Philippine Islands

Causes of Low Acre Yields

Dr. T. Vibar of the College of Agriculture at Los Banos attributes the low acre yields of rice in the Philippines to continuous cropping, the use of inferior varieties, poor seed, lack of good field preparation, lack of water, and damage due to insect pests and plant diseases. These causes are all of such a nature that their effects can be reduced by intelligent efforts, and the rice investigations that are being conducted by the Bureau of Agriculture and the College of Agriculture should result in higher acre yields in the near future.

Rice Imports

The islands do not produce enough rice for home consumption, and as a result considerable rice is imported each year. The imports of rice in metric tons, value per ton, and percentage of the total imports, for the 5-year period from 1920 to 1924, inclusive, are given in Table 13. During this period the imports of rice varied from 42,000 to 151,000 metric tons per year. The imports consist largely of cheap rices from French Indo China and Siam. The per capita consumption of rice in the Philippines in 1920 was 223 pounds; in 1921, 253 pounds; in 1922, 257 pounds; in 1923, 260 pounds; and 259 pounds in 1924.

Table 11. Imports [1] of rice in metric tons, total value, cost per ton, cost per 100 pounds, and percentage of total imports, for the 5-year period from 1920 to 1924, inclusive

Year	Metric tons	Value	Cost per ton	Cost per 100 lbs.	Percentage of total imports
1920	77,334	$8,164,885	$105.58 [2]	$4.80	5.46
1921	59,528	3,324,697	55.85	2.54	2.87
1922	42,295	2,302,157	54.43	2.47	2.87
1923	66,449	3,706,430	55.78	2.53	4.22
1924	151,109	9,262,918	61.30	2.77	8.58

1/ Data from Statistical Bulletin of Philippine Islands. 1924.

2/ This is the highest price ever paid.

According to government officials the islands with little effort could produce enough rice for their own needs, but at present the farmers prefer to grow cash crops such as abaca, coconuts, tobacco, etc. These crops too are not so disagreeable to grow as rice, and they do not require as much constant care. There is, I was told, much fertile land that could be brought under cultivation on some of the islands, and especially in Mindanao. On a great deal of this land rice could be grown with little effort. But due to lack of energy and capital these areas remain comparatively undeveloped. In this respect the Philippines are quite different from Japan and Java, since in these countries practically all of the tillable land is now cultivated. The Philippine Islands no doubt could support a much larger population than it now has and at a higher standard of living.

Crops Other Than Rice

The leading crops other than rice are sugar-cane, coconuts, abaca (Minala hemp), corn, and tobacco. The acreage, total production, yield per acre, and value of these crops for the year 1924 are given in Table 14.

Table 14. Acreage, production in tons, yield per acre, and value of the leading cash crops in the Philippine Islands in 1924 1/

Crop	Acres	Production in tons	Yield per acre pounds	Value b/
Sugar-cane a/	561,159	527,952	1,882	$52,833,590
Coconuts	1,137,287	1,576,629 c/	1,386 e/	34,067,185 d/
Abaca	1,198,791	212,403	470	20,491,140
Corn	1,317,078	500,388	765	16,651,980
Tobacco	178,062	47,655	535	5,752,710

a. Production in raw sugar.
b. Based on prices in municipal markets.
c. Number of nuts in thousands.
d. Value of nuts and coconut products.
e. Nuts.

1/ Data from Statistical Bulletin of Philippine Islands. 1924.

Exports

In 1924 sugar constituted 31 per cent of the total exports from the Philippine Islands; abaca, 22 per cent; coconut oil, 14 per cent; copra, 11 per cent, and cigars, 4 per cent. About 69 per cent of the exports of sugar in 1924, 51 per cent of the abaca, 99 per cent of the coconut oil, 68 per cent of the copra, and about 82 per cent of the cigars were imported by the United States. The total value of imports in 1899 was $19,192,986 and of exports $14,846,582, while in 1924 the value of imports was $108,010,895 and exports $135,344,662. These figures indicate a rather rapid growth of both imports and exports of the islands, since they come under the supervision of the United States.