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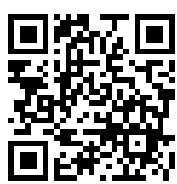

FARMERS' BULLETIN 1141
United States Department of Agriculture

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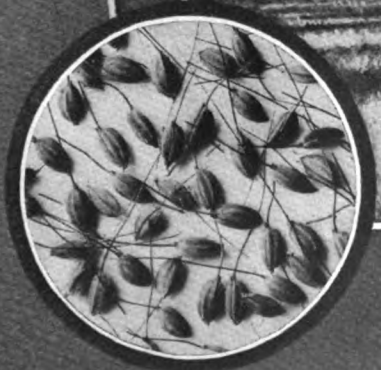
# RICE GROWING in California



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RICE produces its largest yields on clay soils that are not too deficient in organic matter. The land selected for rice culture should lie in level tracts that can be cheaply drained.

The crop requires an abundant and always available supply of fresh water. To obtain good yields of high-grade rice the land must be submerged continuously for several months, and ample drainage facilities also must be provided.

The surface soil of the seed bed should be loose and finely pulverized to a depth of at least 2 inches.

The field levees should be low, broad, and permanent and should be constructed on contour lines at distances which will hold the water at an average depth of 6 inches.

The harvested rice should be put into strongly built shocks well capped to protect the grain from the rain as well as the sun. The rice should remain in the shock for at least one week before thrashing is done.

The short-grain rices are well adapted to the great central valley of California. The long-grain and medium-grain rices do not develop normally in California. They mature later than the short-grain varieties and produce comparatively low yields of grain of poor milling quality.

The worst weed pest in California rice fields is barnyard grass. Land that is badly infested with this grass should be cleaned by fallowing and frequent cultivations before it is sown to rice.

This bulletin is a revision of Farmers' Bulletin 688, The Culture of Rice in California, issued September 18, 1914.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. September, 1920

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# RICE GROWING IN CALIFORNIA.

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CONTENTS.



## HISTORY OF THE EXPERIMENTS.

THE OFFICE OF CEREAL INVESTIGATIONS of the Department of Agriculture began varietal experiments with rice in the vicinity of Biggs, Calif., in the spring of 1909. The experiments were conducted in that locality during the three succeeding years, and during the same period similar experiments were made with a smaller number of varieties at several places in the Sacramento and San Joaquin Valleys. These experimental sowings, which were conducted in cooperation with ranchers, furnished some valuable data on the commercial possibilities of rice culture in California and laid the foundation of a new industry for the State.

In order that these studies might be enlarged and conducted under more favorable conditions, the Biggs Rice Field Station (fig. 1) was established in 1912 with the assistance of ranchers, who organized the Sacramento Valley Grain Association for the purpose of cooperating with the United States Department of Agriculture. The station farm, consisting of 57 acres, is located 4 miles northwest of Biggs and is irrigated by gravity from the Feather River through a canal system operated by a private company. Its soil is black adobe, which is representative of a considerable acreage of land in the Sacramento Valley, on which rice is very productive.

The first commercial crop of rice in California was grown in 1912 on adobe soil in the Sacramento Valley near Biggs. The profits from



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this crop of 1,400 acres were large. The wide publicity that was given to the possibilities of rice culture on black-adobe soil resulted in the sowing of more than 6,000 acres in 1913. The greater part of this acreage was in Butte County, though there were several small sowings in the San Joaquin Valley. The average yield of 3,200 pounds of grain per acre which was produced by the 1913 crop gave so great an impetus to the industry that in 1914 the area sown to rice was increased to 15,000 acres. Since that time rice production has increased rapidly, as is shown in Table I. In 1919 rice was grown on 142,000 acres, and the resulting crop was valued at more than $21,000,000.

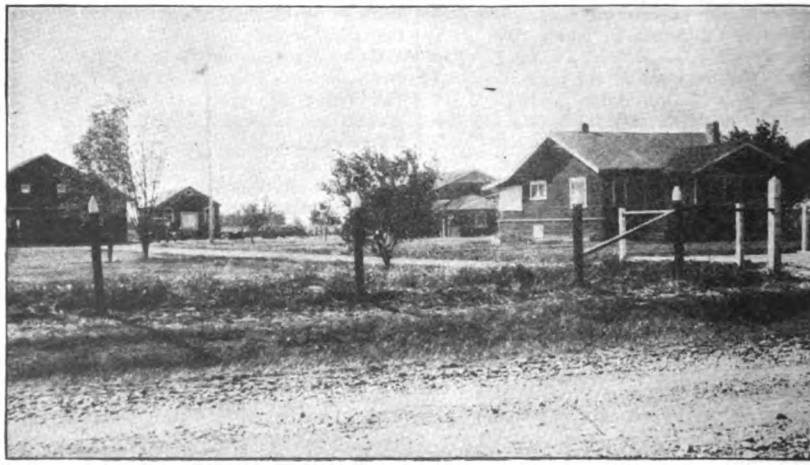

FIG. 1.—Buildings at the Biggs Rice Field Station, Biggs, Calif.

TABLE I.—*Acreage, production, and farm value of rice in California from 1912 to 1919, inclusive.*

| Year. | Acreage. | Yield (bushels). | | Farm value, Dec. 1. | Year. | Acreage. | Yield (bushels). | | Farm value, Dec. 1. |
|---|---|---|---|---|---|---|---|---|---|
| | | Average per acre. | Total. | | | | Average per acre. | Total. | |
| 1912..... | 1,400 | 50.0 | 70,000 | $64,000 | 1916..... | 53,300 | 59.0 | 3,263,000 | $2,545,000 |
| 1913..... | 6,100 | 48.0 | 293,000 | 293,000 | 1917..... | 80,000 | 70.0 | 5,600,000 | 9,800,000 |
| 1914..... | 15,000 | 53.3 | 800,000 | 800,000 | 1918..... | 106,220 | 66.0 | 7,011,000 | 13,321,000 |
| 1915..... | 34,000 | 66.7 | 2,268,000 | 2,041,000 | 1919..... | 142,000 | 55.5 | 7,881,000 | 21,042,000 |

## SECTIONS OF CALIFORNIA IN WHICH RICE IS GROWN.

The rice acreage of California in 1919 was distributed by counties as follows: Colusa, 39,050; Glenn, 34,500; Butte, 34,150; Sutter, 8,700; Yolo, 8,400; Yuba, 6,200; Solano, 3,000; Stanislaus, 2,500; Kern, 1,500; Merced, 1,500; Fresno, 1,000; Placer, 800; Shasta, 700. The distribution of the acreage is shown in figure 2.

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The production of rice at present is confined to the Sacramento and San Joaquin Valleys, the northern and southern sections of a continuous valley more than 400 miles in length and from 20 to 60 miles in width that occupies the north-central portion of the State. To the east of this great valley lie the foothills and forested slopes of the Sierra Nevada Mountains. From this region of heavy precipitation flow many perennial streams which may be used to supply water for a very large acreage of rice. The streams that flow into the valley from the Coast Range do not supply water in dependable quantities for rice production.

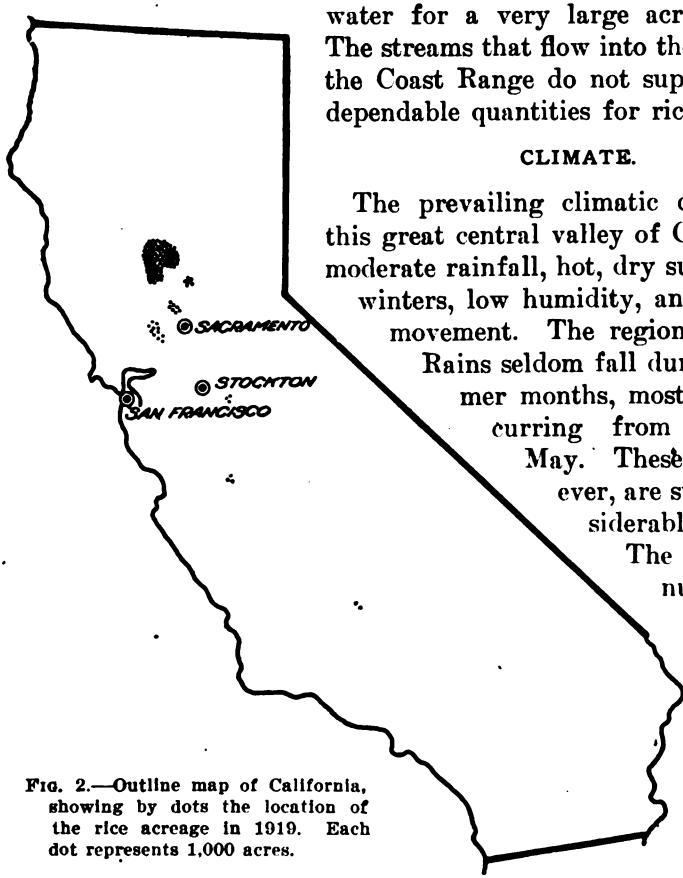


FIG. 2.—Outline map of California, showing by dots the location of the rice acreage in 1919. Each dot represents 1,000 acres.

## CLIMATE.

The prevailing climatic conditions of this great central valley of California are moderate rainfall, hot, dry summers, mild winters, low humidity, and light wind movement. The region is semiarid. Rains seldom fall during the summer months, most of them occurring from October to May. These limits, however, are subject to considerable variation. The average annual rainfall ranges from 24 inches at Red Bluff, at the northern end of the valley, to 5 inches at Bakersfield, at the southern end. The mean annual temperature ranges from 60° to 65° F. The highest temperatures occur in the months of July and August, ranging from 105° to 115° F. During the hot months there is often a daily variation of 40 degrees, resulting in rather cool nights. In the winter, minimum temperatures of less than 25° F. are seldom recorded. The usual minimum is about 28° F. Frosts occur frequently in December and January.

In the Sacramento Valley the prevailing wind during the spring and autumn months is often brisk. Hot, dry winds from the north sometimes occur during the summer months. In their extreme form

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they are called "northers." When they continue for several days, they often do considerable damage to rice, especially if they occur while the crop is in flower.

## SOILS.

The larger part of the rice crop in California is grown on black-adobe soil. This soil contains approximately 50 per cent of clay. In structure it is very close and compact, and it is exceedingly tenacious and puttylike when wet. During the dry season it breaks at the surface into blocks separated by deep cracks. After long exposure to the air these blocks divide and subdivide by smaller cracks until the surface of the soil may become a loose, shallow mass of small pieces the size of peas. The subsoil, which lies at a depth of approximately 3 feet, is gray in color and is rather impervious to water. There are approximately 200,000 acres of this soil in the Sacramento Valley that may be used for the growing of rice.

The Sacramento silt loam, a light-brown soil which occupies a large area in the eastern part of Colusa County, seems well adapted to rice. It is of alluvial origin and varies in depth from 18 inches to 6 feet. In texture and structure it is variable, but as a rule it can be easily cultivated. The heavier type of this soil has a tendency to form hard clods, which are somewhat difficult to reduce.

Good yields of rice are obtained on the Willows clay. This is an indefinite type of soil that occurs in large areas on the nearly level plain south and southeast of Willows. It has a depth of approximately 6 feet. This soil is a reddish and yellowish brown clay that is compact, tenacious, and impervious. It puddles badly when wet and bakes on exposure to the sun. On account of its texture this soil is not easy to cultivate. It contains from 0.04 to 1.2 per cent of alkali.

Rice may be grown successfully on the Alamo clay-loam adobe. This soil varies in color from dark gray to black and in depth from 1 to 5 feet. It is both sedimentary and alluvial in formation and lies upon a red hardpan. It occupies an area that is subject to overflow during the rainy season.

Other types of clay soil in these two valleys are used for rice with success. Fair yields have been obtained on some soils where the surface gave indications of a high alkali content. These salts may be present in relatively small quantity concentrated near the immediate surface. They can be easily removed by the irrigation water, which indicates that with thorough drainage and an ample supply of water for irrigation rice may be profitably used to reclaim these alkali lands. Rice is apparently more resistant than other cereals to alkali salts.

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## GENERAL REQUIREMENTS OF THE CROP.

Irrigation is an important feature in the culture of rice. Water must be applied continuously and at a uniform depth for many days. To meet these requirements the land that is selected for this crop should be level and underlain by a subsoil that is impervious to water. A level tract is better suited to rice than a slightly rolling one, because it is less expensive to prepare and to maintain on account of requiring fewer levees. The impervious stratum of soil should lie near the surface, for a deep soil requires more water and more time for its submergence than a shallow one.

The importance of good drainage can not be too strongly emphasized. Without it a rice field can not be properly drained for harvest. Delay in draining a field at this time may cause a heavy loss in yield. Drainage also is necessary in order to prevent waterlogging, a condition which unquestionably affects the yield. Clay soils, when easily drained and not too deficient in organic matter, seem well suited to the production of rice. Loamy and even sandy soils produce good crops of rice under ideal conditions of irrigation and drainage.

## SOURCES OF IRRIGATION WATER.

The water that is used for the irrigation of rice in the Sacramento Valley is obtained mainly from the Sacramento and Feather Rivers. It is taken out of these streams by gravity or lifted by large pumps for distribution by canals, which are operated by private companies that sell the water on an acre-foot basis or at an annual charge per acre. In the San Joaquin Valley the greater part of the rice acreage is watered from deep wells. They may be used to supplement the gravity supply, though the wells often are the only source of water.

If the water supply is to be developed from wells, the digging of these should precede the seeding of the crop. When this has not been done heavy losses have resulted. The acreage to be watered from a well should never overtax the supply. Until more is known about the underground waters of these two valleys, wells should not be depended upon as the only source of water for rice except in the artesian districts.

The successful growth of this crop depends upon the availability of water at the time of seeding. While it will not always be necessary to apply water for the germination of the seed, it is never safe in California to sow the crop without having a good supply of available water.

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## PREPARING FIELDS FOR IRRIGATION.

Level land with a gentle slope is well suited to the irrigation of rice. With such surface features a field can be irrigated economically and drained satisfactorily if the natural outlets are not too small and are not overtaxed. A rice field must be inclosed by strong levees, in order to hold the water that must be put upon it. As it is also important to maintain a rather uniform depth of water in irrigating rice, the field must be divided into as many subfields, or "cuts," as are necessary to obtain this condition.

A competent civil engineer should be employed to locate the levees, especially those that separate the subfields. These levees should be permanent and should be constructed on contour lines at distances which will hold the water at an average depth of 6 inches. They should be at least 10 feet wide at the base and built up with sloping sides to a height just sufficient to prevent the water from overflowing into the subfields below. All kinds of farm machinery easily pass over levees of this character without damaging them. This simplifies field operations, for such levees make possible the cultivation of an entire field as a unit instead of the separate cultivation of "cuts," which is necessary where high, narrow levees are used. These broad levees are advantageously seeded to rice in sections where there is considerable rainfall during the growing season. In the great central valley of California, which is semiarid, the conditions on the levees are not suited for good plant growth, but they should be sown to rice in order to control weeds.

Firm and compact levees are necessary to reduce seepage. They should be constructed or rebuilt during the winter. When constructed at this time they are more serviceable than when made just before water is applied. It is better to build new levees at least one-third higher than the stated requirement, thus allowing for settling and washing.

The water is admitted to subfields through openings in the levees. These openings should be controlled by wooden gates and not made with a shovel each time water is needed. The gates should consist of a floor and end pieces to hold a sliding shutter in a vertical position across the opening. The flow of water may be regulated by the shutter, which consists of narrow pieces of wood that may be increased in number or removed as the water is raised or lowered.

## VARIETIES.

The leading rice varieties of California are the short-grain rices, the Wataribune and two unnamed varieties known as C. I. No. 1564

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and C. I. No. 1600. They are very hardy and produce large yields, but require a long growing season.

Early-maturing rices are very desirable for the Sacramento Valley. No variety maturing within five months at the Biggs Rice Field Station possesses quality and yielding capacity that would make it valuable for commercial purposes.

The long-grain and medium-grain rices, represented, respectively, by the Honduras and Blue Rose varieties, which are very productive in Louisiana, Texas, and Arkansas, have not been successfully grown experimentally or commercially in California. They do not develop normally (fig. 3), mature later than the short-grain varieties, and produce comparatively low yields of grain of poor milling quality.

FIG. 3.—Two heads (botanically called panicles) of the Honduras variety, a long-grain rice. These heads have not emerged completely from the leaf sheath. This is characteristic of all long-grain and medium-grain rices that have been tested in California. Plants that mature in this manner do not produce large yields of grain of good milling quality.

The Wataribune variety (fig. 4) has short, broad seeds which average in length four and in width seven to the inch. The hull is light yellow in color and bears a light-yellow awn, at the base of which are tufts of short white hairs. Many of the awns drop before the crop is harvested and those that remain are usually broken off in thrashing and in handling the sacks, so that this variety often goes to the mill with very few, if any, awns attached.

The seed of the Colusa variety (C. I. No. 1600) has a light-yellow hull thinly covered with short white hairs and is awnless (fig. 5). This rice matures earlier than the Wataribune variety. On rich



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new land it produces large yields, but is less productive on old rice land because it tillers less under these conditions.

The hull of the seed of the Butte variety[1] (C. I. No. 1564) is light yellow in color (fig. 6). It is thinly covered with short white hairs and bears a light-brown awn, which remains tightly attached. This variety grows well on land that has been previously cropped to rice, but it does not tiller as heavily under these conditions as the Wataribune and for this reason should be seeded at a rate of 25 per cent greater. The grain does not shatter readily, which is an advantage at harvest if for any reason cutting is delayed, but somewhat of a disadvantage in thrashing, especially if the straw is not thoroughly dry.

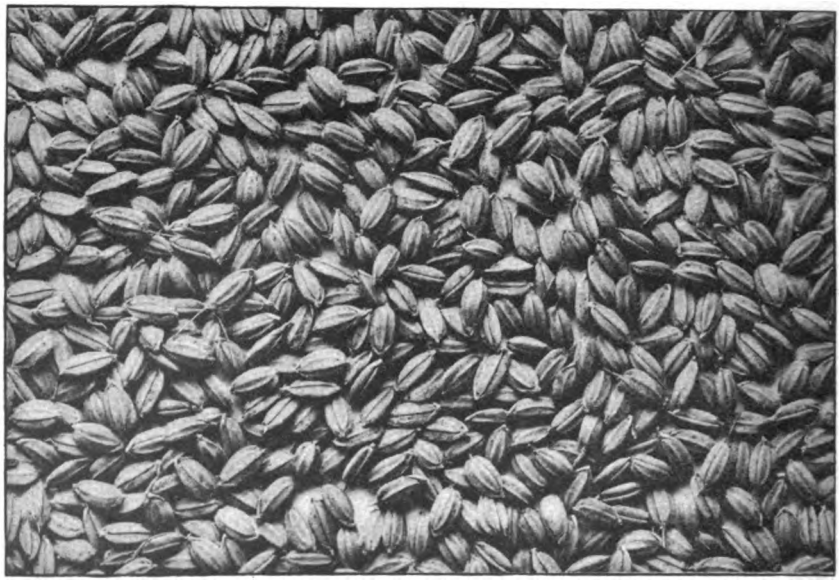

FIG. 4.—Seed rice of the Wataribune variety. (Natural size.)

Each of these three varieties, when seeded early in April on well-prepared land, produces an average yield of over 4,000 pounds per acre. The last two varieties mature approximately a week earlier than the Wataribune rice, and the grain which they produce is similar to it in size and quality.

## PREPARATION OF THE SEED BED.

When not contrary to good farm management and when the nature of the soil will permit, plowing should be done in the late autumn. There should be good drainage, so that the winter rains will wash

[1] These varieties, which have been quite widely distributed under Cereal Investigations Nos. 1600 and 1564, respectively, are now named Colusa and Butte, the names of two of the leading rice-producing counties in the Sacramento Valley.

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out any alkali which may have accumulated in the surface soil. Deep plowing should be practiced. The action of the rain during this period will reduce the clods, which will lessen the amount of disking and harrowing necessary for preparing a good seed bed the following spring.

If plowing is delayed until spring, the land should not be left rough, but should be disked and harrowed at once and not allowed to dry before sowing.

The vigorous growth of the young plants, as well as high germination, is dependent on a seed bed with a surface soil that is loose and finely pulverized to a depth of at least 2 inches.

FIG. 5.—Seed rice of the Colusa variety (C. I. No. 1600). (Natural size.)

## PREPARATION OF THE SEED.

All seed rice should be graded and cleaned before it is sown. A fanning mill may be used for this purpose. Ungraded seed is likely to produce a poor stand, and the use of uncleaned seed is one way by which weeds are introduced or increased in a field. Although rice without hulls may germinate under favorable conditions, seed rice containing it is inferior for seeding purposes. It is more easily damaged by unfavorable weather following seeding than the seed with the inclosing husk or hull. The use of seed containing rice without hulls results always in a thin stand or a stand with many weak plants.

Seed rice should always be tested for germination, as it may have been exposed to conditions that have affected its germinating power.

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For a germination test several lots of 100 seeds each should be taken from a sample of the seed to be sown. Each lot should be placed separately between blotting papers or Canton flannel and kept moist at a living-room temperature (70° F.) for at least a week. The number of seeds that have strong sprouts should then be counted. Seed that shows low vitality should not be sown, but, if it must be used, the rate of seeding should be higher than that commonly recommended for the variety.

## METHOD OF SEEDING.

In sowing rice the seed should be distributed evenly and covered uniformly. These results are more easily obtained by drilling the

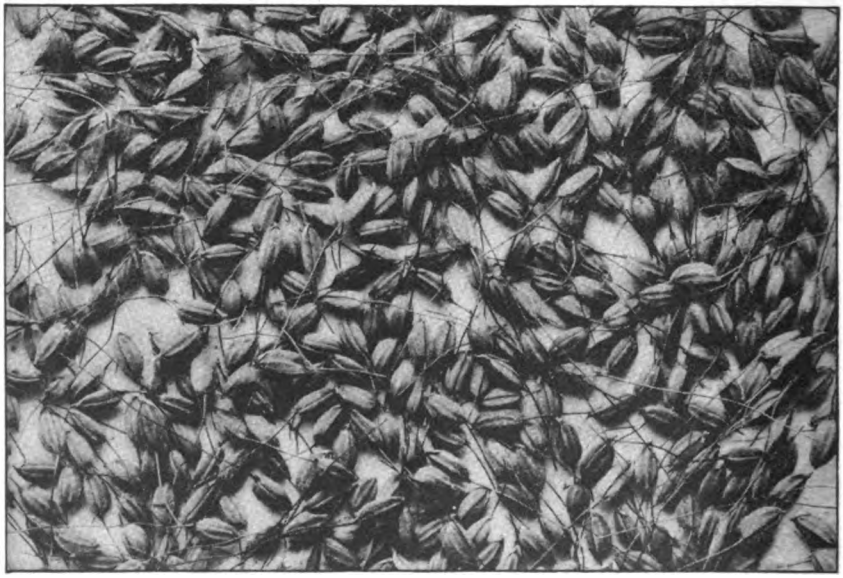

FIG. 6.—Seed rice of the Butte variety (C. I. No. 1564). (Natural size.)

seed than by broadcasting it. When drilled, less seed is required, and as a rule a more uniform stand is obtained. Any one of the ordinary forms of drill may be used if the seed bed is in good tilth.

## TIME OF SEEDING.

In California approximately six months are required to mature a crop of rice, and for that reason early seeding should be practiced. The crop should be sown early enough to be harvested before the autumn rains begin. If seeded at an early date the crop will flower under normal conditions during the period of high temperatures, with a resulting increase in yield and improvement in quality. The risk of losses from wet weather increases as the harvest period comes later. In a date-of-seeding experiment at the Biggs Rice Field Sta-

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tion, in which rice was sown every 15 days from April 1 to May 15, inclusive, the early seeding has invariably produced the largest yields. The yields from each successive sowing were from 400 to 500 pounds per acre less than from the preceding one. The same proportional decrease in yield was noted on the commercial fields near Biggs. April 1 is recommended as the approximate date for sowing rice in California. It is not safe to sow rice in that State after May 1.

## RATE OF SEEDING.

The quantity of seed that should be sown varies with the variety of rice, the vitality of the seed, the fertility of the soil, the character of the seed bed, and the method of seeding. Under ordinary conditions, on black-adobe soil, 90 pounds of seed to the acre are sufficient for the Wataribune variety.

Thin seeding may induce excessive tillering, which invariably results in irregular ripening and low yields. On a good seed bed less seed will be required than will be necessary to get an average stand on a poorly prepared one. If weedy land is used, the rate of seeding should be greatly increased. It is always necessary to use more seed in broadcasting than in drilling.

## DEPTH OF SEEDING.

Rice should be sown under ordinary conditions at a depth not exceeding 2 inches, but a greater depth may be required on a cloddy field in order to cover the seed well. With proper moisture conditions shallower seeding is desirable on a well-prepared seed bed. When irrigation is necessary to obtain germination, the seeding should not be too shallow or the water may float and scatter the seed.

## TIME TO APPLY IRRIGATION WATER.

On typical adobe soil, and probably on all of the clay soils on which rice may be grown, it may be necessary to apply water to germinate the seed. A seed bed on these soils loses its moisture very quickly. Under normal weather conditions a good seed bed on soils of lighter texture may not require the application of water for germination. Such soils, if well drained, permit very early seeding, which is always an advantage in California.

Great care should be taken in irrigating to cause germination. Soil and atmospheric temperatures are usually low at this season of the year, and if water is left on the land too long the seed is likely to rot. Before the plants come up, water should not be allowed to remain on the land longer than 24 to 48 hours after each irrigation. After seeding, the soil should never be allowed to become dry. This

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will require frequent irrigation, and a supply of water should always be available and abundant enough to meet the requirements.

According to experiments at the Biggs Rice Field Station, the subfields should be submerged about 30 days after the plants have emerged. The depth of water should be increased slowly until the maximum depth of 6 inches is obtained. By this time the plants should have reached a height of at least 18 inches. Throughout the growing season this depth is maintained, fresh water being applied when needed to supply losses from seepage, evaporation, and transpiration.

Paying crops of rice can not be produced without submerging the land continuously for a period of several months. The growing of rice on soil that is merely kept moist and not submerged should not be considered.

The amount of water required to make a good crop of rice depends largely upon how well the outside levees have been constructed and what quantity of water is allowed to flow through the field. To conserve water, the levees should be as near seepage proof as possible. Poorly constructed outside levees are responsible for the loss of much water.

The levees that inclose the field should be firm and compact. If they are next to a field that is not under irrigation, they should be very broad. Seepage is greater through levees that are constructed of black adobe than through levees that are made of other types of clay.

A further loss of water often results from allowing too much to flow through the fields, in an effort to keep the water fresh. After a field has been submerged no more water should be admitted than is necessary to retain the required depth. This will be rather small if no loss occurs through seepage. The overflow of water should be no more than a mere film. From many fields it is often several inches. This is an extravagant use of water and should not be practiced.

Too much attention can not be given to levees and to the delivery and discharge of water. Payment for water should be based upon the volume delivered. Upon this basis it would be more economically used than can reasonably be expected when sold on a flat charge per acre.

Under the climatic conditions of California about 5 acre-feet of irrigation water are required to produce a good crop of rice.

## DRAINAGE.

The irrigation water should be removed promptly from the field when the crop is ready to be harvested. To do this effectively, ample provision should be made for drainage. This will require a number of ditches of sufficient depth and width to remove the surface water

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and to drain the soil thoroughly. These ditches must be kept free from all kinds of obstruction, especially from weeds, which grow luxuriantly in them, or their capacity will soon become greatly reduced.

The number and the location of these ditches depend on the surface features of the land under cultivation. The surface water should be carried away quickly. This can be done by connecting the field outlets with watercourses or artificial channels of sufficient capacity. The latter is an engineering problem requiring community cooperation and can be readily solved in many localities by the creation of drainage districts.

On fields that drain slowly there is always delay in harvesting the crop, which invariably results in the loss of grain from shattering. Lack of drainage or poor drainage facilities will also increase the cost of production through the additional time and labor required to cut and move the crop from a boggy field. During the winter all drainage outlets should be kept open, so that surplus water will not remain on the land. This attention will prevent water-logging and the accumulation of harmful alkali salts in the surface soil and will also aid in the aeration of the soil. The importance of having control of these conditions is strongly emphasized, for without good drainage maximum yields can not be obtained.

## HARVESTING THE CROP.

A twine binder should be used in cutting the crop. Rice is ready to harvest when the kernels on the lower part of the head (botanically called the panicle) are in the hard-dough stage. This stage of maturity is indicated by the position of the heads, the tips of which are then well turned down. If cut earlier, a large percentage of the kernels will be imperfectly filled. If cut later, the loss from shattering is likely to be heavy, for rice shatters badly when left standing until fully ripe. The harvesting of rice is shown in figure 7.

## SHOCKING.

The milling quality of rice is greatly improved by prompt and careful shocking. As soon as the grain is cut the sheaves should be put in round shocks, which should be strongly built to withstand wind. The protection from the sun which the grain gets within the shock reduces the percentage of cracked kernels and consequently increases the value of the rough rice. While the harvested grain is likely to be damaged in California more from exposure to the sun than from dampness caused by rains, the losses from the latter cause may be heavy, making it important to cap the shocks for protection against rain as well as sun.

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In building a shock the first two bundles should have the butts firmly set into the stubble sufficiently far apart to be well braced when the heads are brought together. Place around these 8 to 10 bundles in such a manner as to form a round shock, making provision at the same time for free circulation of air. Select a large bundle to serve as a cap. Slip its band down to the heads and put it in an upright position with the heads down and in contact with the heads of the bundles forming the shock. When it is in this position open the bundle from the center by bending the straw at the band. Pull down the straw and spread it evenly to make a covering for the heads of the cap bundle and the underlying bundles.

When the straw is wet or not entirely ripe, it is probably safer to build a smaller shock. A field of shocked rice is shown in figure 8.

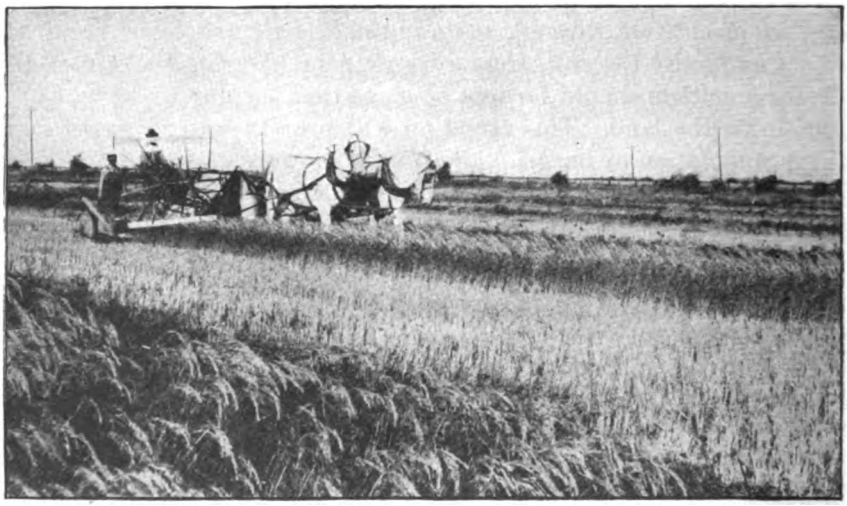

FIG. 7.—Cutting rice with a twine binder. Before harvest the irrigation water is drained from the field.

## THRASHING.

Rice should not be thrashed until the kernel is hard and the straw thoroughly dry. This requires at least one week in the shock. If the weather is rainy this period may be considerably prolonged. The damage to the grain in a well-constructed shock exposed to rains is negligible compared to the loss that may occur when thrashing is done too soon. The grain should not be thrashed too early in the day, even though it has been cured thoroughly in the sun. If thrashing is attempted while the straw is damp with dew the separation is likely to be poor, with a resulting loss of grain. There is danger, also, of further loss by heating if the grain is sacked and stored while damp. When thrashing is done under contract or where more than one variety is grown on a farm, special attention should be given to

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the cleaning of the separator. This is necessary in order to keep varieties as pure as possible and to prevent the introduction of weeds from neighboring farms. Rough rice is greatly improved in grade by careful thrashing. Too much attention can not be given to the adjustment of the concaves to prevent hulling and cracking. (Fig. 9.)

## WEEDS.

Under the general term of "weed" may be included those plants that interfere with the full development and marketing of any crop. The plants that normally inhabit wet places find in a rice field ideal conditions for rapid and luxuriant growth, and if not eradicated when they first appear may cause heavy losses. Because of abundant seed production and their general hardiness they are not easily controlled. Their presence in a field adds to the cost of production, reduces the yield, and produces an inferior grade of

FIG. 8.—A field of shocked rice in the Sacramento Valley.

grain. Rice containing weed seeds always sells for a lower price than clean rice.

The eradication of weeds is expensive, and it is therefore important to use every method to prevent their introduction. Most weeds are probably introduced into fields by sowing seed rice that has not been thoroughly cleaned. The irrigation water furnishes another source of infestation, being supplied from the weed growth in ditches and on ditch and canal levees. The community thrashing outfit also acts as a weed distributer.

The danger from these sources can be greatly minimized by the exercise of care, cleanliness, and good judgment. Weeding by hand should be resorted to as soon as weeds appear in a field, unless their number is so great that the cost makes it prohibitive. In the latter case the land should be fallowed and occasionally irrigated to germinate the weed seed. No weed should be allowed to mature its seed. This applies to weeds on roads and levees as well as to those

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in the field. The former can be handled easily and cheaply by the use of mowing machines and scythes. The seeding of field levees to rice will reduce the area for weed growth.

### BARNYARD GRASS.

Barnyard grass,[1] which is locally known as water grass, is the worst weed to be found in the rice fields of California. It is a coarse, erect, or spreading annual, varying in height from 12 to 48 inches. It is widely distributed in all cultivated regions and grows luxuriantly in fields that are continuously irrigated. This weed produces a large number of seeds. On a single plant there may be as many as 40,000 seeds. It is therefore not safe to allow a single plant to go to seed in a rice field, for with such seeding habits it would soon populate the field. During the last five years this grass has taken complete possession of several thousand acres of rice land

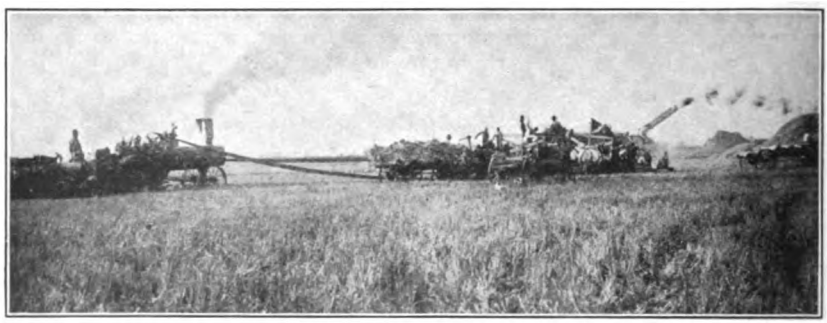

FIG. 9.—Thrashing rice in the Sacramento Valley.

in the Sacramento Valley and is now present in alarming quantities on a considerable acreage, which will soon be rendered unprofitable for rice growing unless active steps are taken for its complete eradication or control. A commercial sample of rice containing many seeds of barnyard grass is shown in figure 10.

This weed has probably been more widely distributed through the use of seed rice containing its seed than by any other means. Water from irrigation ditches upon the banks of which it has been allowed to grow contributes its quota of seed. The seed of this grass also is carried from one field to another by the floods which sometimes occur during the winter.

Seed rice containing the seed of barnyard grass should not be used. As soon as this grass appears in a field it should be removed by hand before it goes to seed. Its seed usually germinates with the rice, and in about two weeks after coming up it shows a more vigorous growth and a lighter green color than the rice plants. Rice requires approxi-

[1] *Echinochloa crus-galli* (L.) Beauv.

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mately six months from seeding to harvesting in California, while barnyard grass matures its seed in from two to three months. It is possible, therefore, for this pest to produce two crops of seed before rice is harvested. This shows the importance of preventing the growth of barnyard grass in rice fields.

The only satisfactory method known at present for the eradication of this weed is to remove it from the field by hand. On account of their large root systems it is not practicable to pull up the plants. They should never be cut off at the surface of the ground, as is often done, for a new growth will develop and produce seed in about 40 days. The plants should be cut below the crown, which is usually

FIG. 10.—A commercial sample of seed rice of the Wataribune variety, containing many hulled grains and the seeds of barnyard grass. (Natural size.)

covered with 2 inches of soil. Plants which have been cut at the surface have been known to produce seed as many as four or five times during a season. As soon as they have been cut the plants should be removed from the field, for they will continue to grow if they are allowed to remain in moist or wet places.

It has been found practicable and advisable to cut this grass from fields even when the growth is very heavy. The cost of eradication will depend largely on the quantity in the field and on the class and cost of the labor employed. If this weed is allowed to seed in any quantity during the first year, it is almost impossible to eradicate it during the second year.

At present summer fallowing seems to be the best method to obtain the complete eradication of this weed. The conditions should first

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be made favorable for the germination of the seeds that are in the soil. After germination the plants should not be allowed to produce seed. This can be done effectively by frequent shallow cultivation after the seed germinates. Irrigation probably will be necessary to assure germination.

In eight years this weed has become a menace to the rice crop of the Sacramento Valley. For the control or the eradication of this grass community, county, or State action is imperative if the rice industry of California is to reach its maximum development and permanency. Such agencies probably will never become effective until the greater part of the land cropped to rice is owned by the producers. Without such ownership the creation of a sentiment in favor of control by law is very remote. Any measure that may be employed now must carry with it full police powers to be effective.

### RED RICE.

In the Southern States the worst weed of the rice fields is red rice. This weed has been introduced into California through the purchase of seed rice from the South. It is well distributed throughout the rice-producing countries of the world. Foreign seed may contain as much red rice as domestic seed, so there is also danger from this source. The seed coat of the kernel of this rice is red, which distinguishes it readily from the white rices. It is introduced only through the use of seed containing red rice. In discussing seed rice from the standpoint of red rice only, the importance of pure seed can not be overestimated. After heading, red rice can be readily distinguished from our commercial varieties by its loose, open, slightly drooping head with comparatively few grains on the branches.

A slight infestation of a small acreage may be easily controlled during the first year by pulling up the individual plants and removing them from the field. If this is not done, the quantity of red rice may greatly increase during the second year, for the seed of this rice shatters very badly. Some of it may be harvested and thrashed with the main crop, but the quantity will be proportionately small, though large enough to affect the grade. The presence of red rice always lowers the value of the crop.

### WILD OATS.

The wild oat [1] is not a troublesome weed in the rice field, though it often makes a vigorous growth in fields where the stand is thin. It is usually brought under control when the first continuous irrigation water is applied.

[1] *Avena fatua* L.

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### CANARY GRASS.

Canary grass,[2] which thrives in wet soil, has caused loss in some fields. It germinates with the rice and, as it grows much faster, it may seriously affect the early growth of the crop if it is very abundant. While canary grass may never become a troublesome weed, it should not be allowed to establish itself in a rice field. It should be removed by hand when it first appears.

## DISEASES AND INSECTS.

In the rice-growing sections of the Southern States the rice plant is subject to attack by four diseases and several species of injurious insects. None of these, or of any other species of fungi or insects, has been found in or reported to affect the rice crop of California.

## RICE PRODUCTS.

Rice leaves the thrasher with the hull or husk attached. It is called rough rice and in this condition is sold to the miller. In the mills it is prepared for the market. After the removal of the hull and seed coat, or skin, the kernels are polished. The polishing improves the commercial value of the rice, but decreases its food value.

After the rough rice has been cleaned in order to remove all kinds of trash, it is conveyed to the milling stones, between which the hulls are removed. From these stones it passes over horizontal screens, where the hulls and the whole and broken kernels are mechanically separated. The unbroken kernels are now conveyed to a set of machines known as hullers, in which the outer skin and much of the gluten layer of the grain, together with the germ, are removed by friction. After leaving the hullers the rice is screened and fanned, to free it from the bran. It is again subjected to another scouring in a second set of hullers or in a pearling cone. It is now ready to be polished, a process which gives the kernels the pearly luster that is demanded by the general trade. In the polishing process more of the gluten layer and many layers of starch cells are rubbed off. This product is called rice polish. After the polishing the rice is screened. If it is to be coated with glucose and talc, as is generally done, it is conveyed to a revolving cylinder where the coating material is applied. The different grades of cleaned or milled rice are afterwards separated.

The unbroken kernels of milled or cleaned rice are known as head rice. This kind of rice always commands the highest price and is sold under several grades, which vary in the different markets but are separated largely according to the brilliancy of the polish and the color and size of the kernels. The broken kernels may be

[2] *Phalaris paradoxa* L.

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sold as ordinary or broken rice, screenings, or brewers' rice. The last grade is composed of very fine particles of the kernels.

The principal feeds that are obtained from rice are bran, meal, and polish. The bran is composed of the seed coat and the embryo, with varying quantities of hulls. Bran that contains no hulls or comparatively few is called meal. It is the most nutritious of the rice feeds and when fresh is very palatable to domestic animals. On account of its high percentage of fat it often becomes rancid if kept too long. In the polish the percentage of fat and protein is much lower than in the meal, while the percentage of starch is much higher. Polish is used for feeding cattle and pigs.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

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