RICE CULTURE in California

FARMERS' BULLETIN No. 2022
U. S. DEPARTMENT OF AGRICULTURE

THE commercial production of rice in California began in 1912, when 1,400 acres were sown. In 1949 the area was 290,000 acres. The annual rice acreage fluctuates, but during 1939–49 it averaged about 190,000 acres.

Rice growing is confined largely to the heavy clay and clay-adobe soils of the lower Sacramento Valley, where a reliable supply of water is available for irrigation. Rice requires high temperatures during the growing season, a dependable water supply for irrigation, level land with an impervious subsoil, and good surface drainage.

Land on which rice is to be sown is usually spring-plowed and then harrowed or the clods crushed with heavy wooden or iron floats (drags). The land is then submerged and the seed is sown broadcast on the water, largely by airplanes. Seed sown on water is seldom covered by clods, while that sown on the surface of soil is frequently covered by slaked clods, which prevent normal germination and thus often cause poor stands. Early seeding, at the rate of 145 to 160 pounds on land to be continuously submerged thereafter and at the rate of 130 to 150 pounds when sown directly on the water, usually gives the best results. The leading varieties of rice now grown in California are Caloro, Colusa (C. I. 1600), Onsen, and Calrose.

Weeds, particularly water grasses, are the most troublesome pests in California rice fields. They can be controlled to a considerable extent by seeding on the water or by continuous submergence after broadcast seeding.

This bulletin supersedes Farmers' Bulletin 1240, How to Grow Rice in the Sacramento Valley.

Washington, D. C. **Issued September 1950**

COVER ILLUSTRATION—Airplane seeding of rice in California.

RICE CULTURE IN CALIFORNIA [1]

By Jenkin W. Jones, *principal agronomist*, Loren L. Davis, formerly *associate agronomist*, and Arthur H. Williams, *assistant agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

Contents

INVESTIGATIONS begun by the United States Department of Agriculture in the spring of 1909 and continued for 3 years provided information that indicated the commercial possibilities of rice culture in California. The first commercial rice crop was grown in California in 1912 on Stockton clay-adobe soil in the Sacramento Valley, near Biggs. The high yields per acre and large profits from this crop of 1,400 acres received wide publicity, which stimulated interest and resulted in the rapid expansion of the California rice industry. In 1914, 15,000 acres were sown; in 1915, the crop was grown on 34,000 acres. The need for and high price of rice during the world wars caused a further increase in acreage and production. In 1949, 22,040,000 bushels of rice were produced on 290,000 acres—a record.

IMPORTANCE OF THE RICE CROP

The area on which rice can be profitably grown in the United States is much more limited than that on which most of the other cereal crops can be produced with profit. Rice is well adapted, however, to certain sections.

During the 5-year period, 1943–47, California produced 22.2 percent of the total rice crop of the United States on 15.4 percent of

[1] For a more complete discussion of rice production in California, together with the details of the experiments on which many of the recommendations in this bulletin are based, see U. S. Dept. Agr. Dept. Bul. 1155, Rice Experiments at the Biggs Rice Field Station in California; U. S. Dept. Agr. Dept. Bul. 1387, Experiments in Rice Culture at the Biggs Rice Field Station in California; U. S. Dept. Agr. Farmers' Bul. 1240, How to Grow Rice in the Sacramento Valley; and U. S. Dept. Agr. Tech. Bul. 718, Fertilizer Experiments with Rice in California. Out of print, they may be consulted in libraries.

the total acreage. The average yield per acre in California is higher than that obtained in other large rice-producing States.

In California rice ranks second among cereal crops in total production and also in total value, being exceeded only by barley. Rice, although occupying less than one-seventh of the average barley acreage and less than two-fifths of the average wheat acreage during the 5-year period 1942–46, had a value equal to about 56 percent of that of the barley crop and about 153 percent of that of the wheat crop in California. Rice is grown chiefly on land that was used for wheat and barley prior to the introduction of rice, so that under rice culture this land is much more productive of wealth than it was when wheat and barley were grown.

RICE-GROWING REGIONS

There are three main rice-producing regions (fig. 1) in the United States:

1. The broad level prairie region of southwestern Louisiana and southeastern Texas, where rice growing began on a commercial scale about 1885. Irrigation water for this section is obtained by powerful pumps from sluggish streams or bayous, which provide drainage for the prairies. Water is also pumped from wells. This is the most important rice-producing region in the United States.

2. The prairie region of eastern Arkansas, where rice growing began commercially in 1905. The irrigation water for this section is largely pumped from wells.

3. The interior valleys of California, where rice growing began on a commercial scale in 1912. The irrigation water for this section is obtained largely from streams by gravity or pumps, or from wells. Most of the crop is produced in the Sacramento Valley in Sutter, Colusa, Butte, Yolo, and Glenn Counties.

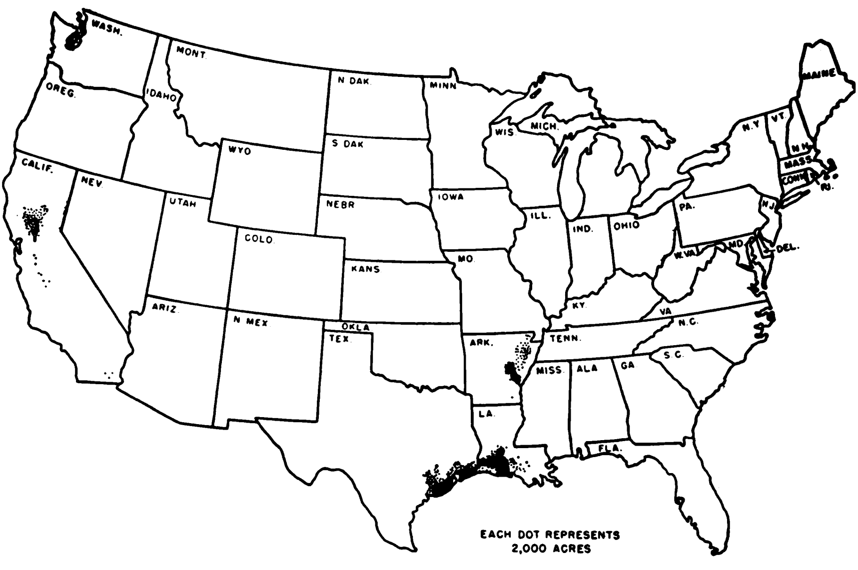

Figure 1.—Areas of rice production in the United States, showing average yields for 1941–45.

REQUIREMENTS OF THE CROP

Successful rice culture is dependent upon high temperatures during the growing season, a dependable water supply during the period of irrigation, soils that are comparatively flat or level and underlain with an impervious subsoil, and good surface drainage.

In California, clay and clay-adobe soils with an impervious subsoil from 1½ to 6 feet below the surface require less water to produce a crop than do the lighter soils. After draining in the fall, these heavy soils usually dry out and crust at the surface more quickly than the lighter soils, thus making possible the use of heavy machinery in harvesting the crop. Level land can be prepared for rice irrigation at a much lower cost per acre than slightly rolling or uneven land. The larger checks on level land are also more economical for seedbed preparation and harvesting than the small checks necessary on uneven land.

Good drainage is as essential in rice culture as in wheat culture, for without adequate drainage it is difficult to obtain good stands in the spring and practically impossible to drain the land effectively for harvest when the crop is nearing maturity. Poorly drained fields are difficult to cultivate and expensive to harvest. Good surface drainage therefore is essential for maximum yields produced at a minimum cost.

CLIMATE

In the Sacramento and San Joaquin Valleys the summers are hot, with low humidity. Maximum temperatures during June, July, and August range from 105° to 115° F. During these months a daily range in temperature of 40° is not uncommon. The nights are comparatively cool, even during the hottest months. The winter months are usually mild, though freezing temperatures are not uncommon in December, January, and February. These also are the months of highest precipitation. The average annual rainfall at the Biggs Rice Field Station for the 34-year period from 1913 to 1946 was 20.60 inches.

The average evaporation from a water-free surface from April 1 to October 31, inclusive, for an 8-year period was 42.05 inches. Strong winds seldom blow, though it is often windy in early spring and late fall.

SOILS

The rice crop in California is grown on various soil types. The heavy clays and clay adobes that are underlain with an impervious subsoil at depths ranging from 18 to 36 inches are best adapted to this crop. These heavy soils are hard to cultivate. If plowed when too wet they bake; if too dry, they turn in large clods, which are difficult to reduce. These soils require from 4 to 7 acre-feet of water to mature a rice crop; lighter soils may require from 8 to 10 acre-feet. Heavy soils when drained in the fall usually dry out and crust at the surface in from 10 to 14 days, so that they will support heavy harvesting machinery. Most light soils, however, dry more slowly and do not crust at the surface as quickly, so that it is often necessary to harvest in the mud—an expensive operation.

ROTATIONS

The rice industry of California is comparatively young, and no definite system of crop rotation is yet being followed. The heavy soils on which rice is grown and the high water table during the submergence season make it difficult to find crops that can be grown profitably in a rotation with rice. The nearest approach to a rotation system at present is on new land that has been used for two or three successive rice crops. These crops are followed by spring- or summer-plowed fallow on which wheat or barley is fall-sown, and then rice is again grown for 1 year. By this method only one rice crop is grown in 3 years.

At the Biggs Rice Field Station attempts have been made to grow cultivated crops in rotation with rice, but corn, grain sorghums, cotton, and beans have not produced a profitable crop. Until more information is available on other crops it seems advisable to use the crops that were produced before rice growing began—wheat and barley. These crops mature before the water table has risen sufficiently to interfere with growth. Although very good yields of wheat and barley have been reported on fallowed riceland, some growers do not think that these crops are profitable under such conditions. They prefer to alternate rice and fallow or to have two rice crops and one fallow. The growing of wheat or barley following rice without fallowing is seldom practiced, for the yields are usually low. Field peas, horsebeans, and beans are grown to some extent in rotation with rice as cash or cover crops to be turned under, but none of these crops is grown extensively.

A second and the most common method is to alternate a rice crop and fallow. The rice stubble is spring-plowed dry for fallow, then prepared for rice the following spring. Some growers do not fallow, but leave the land uncropped and uncultivated until it is prepared for rice the following spring. Such idle lands are often pastured (fig. 2).

Figure 2.—Sheep grazing on uncultivated (idle) riceland.

Much land that formerly was sown to rice is now used for improved pastures consisting of Ladino clover or a mixture of Ladino clover and grasses. The land for improved pastures is leveled, a good seedbed is prepared, and levees for irrigation are constructed on contour lines or to form rectangular checks. The improved pastures must be irrigated and promptly drained each 7 to 14 days during the warm summer months. Hence, good surface drainage is essential, for in hot weather standing water is injurious to the clover. Fences usually separate the pasture into units that are grazed alternately, largely by cattle and sheep.

Much of the land in improved pastures has not been put back into rice, although some fields have been plowed and again sown to rice. With good stands the yields of rice on improved pasture lands are relatively high. Observations indicate that improved pastures should be plowed early in the spring or the previous fall, so that the organic matter turned under will largely be decomposed by the time the land is submerged and the rice sown. Otherwise the stand of rice may be poor.

FERTILIZERS

The three plant-food elements most likely to be deficient in soils are nitrogen, phosphorus, and potash. Since the industry began, growers have been interested in the possibility of maintaining or increasing rice yields by the use of fertilizers. The water used for irrigation in California is comparatively clear, and therefore adds little, if any, silt or plant-food elements to the soil.

The new ricelands are very productive, but yields are usually materially lower with each successive crop. The reduced yields may be due to a lack of plant-food elements, competition with weeds, poor physical condition of the soil, lack of humus, poor drainage, or unfavorable conditions for soil micro-organisms.

Fertilizer experiments with rice at the Biggs Rice Field Station clearly indicate that the Stockton clay-adobe soil is deficient in nitrogen. Tests also indicate that other rice soils of California are also deficient in this element. Nitrogen can be added to the soil as commercial fertilizer or by growing a leguminous crop to be plowed under. The second method should be followed wherever possible, as it adds organic matter and thus improves the physical condition of the soil as well as supplying nitrogen. Decaying organic matter helps to make other plant-food elements more readily available.

Rice growers of California appreciate the fact that a good growth of bur-clover, a winter-legume crop, turned under at the proper time in the spring materially increases the yield of rice. Great care must be taken, however, to assure the desired results. It is difficult to obtain a good stand of bur-clover on old riceland, but, on the other hand, if a heavy growth is obtained and turned under too late in spring on land that is continuously submerged, the stands and yields of rice may be reduced because of excessive vegetative growth, often resulting in some sterility and lodging.

Bur-clover grows best on well-drained soils. In cold, wet winters the stand and growth of this crop often are very poor. Attempts have been made to obtain stands of bur-clover by seeding on fallow land in September. After seeding, the land may be irrigated to germinate the seed and maintain suitable moisture conditions for early growth. In favorable years good stands have been obtained in this way; in unfavorable years failure has resulted.

Weather conditions must be favorable to get good stands of bur-clover. If the weather is too cold or dry and hot following fall irrigations, stands are poor. The germination of bur-clover seed appears to be very uncertain. Most farmers who sow bur-clover seed on fallow land now depend upon rainfall to germinate the seed and maintain suitable moisture conditions for growth. Other farmers irrigate the fallow or idle land in the fall and depend upon the clover seed present in the soil for profitable stands. Fall irrigation also germinates a good deal of water grass seed (*Echinochloa crusgalli*), but this pest is later killed by frost.

Rice yields at the Biggs station have been materially increased by the application, just before seeding, of such nitrogenous fertilizers as ammonium sulfate, uramon, urea, and cyanamide at the rate of 100, 150, or 200 pounds per acre. The increased yields were sufficient to give a fair profit after deducting the cost of the fertilizer, the cost of application, and the expense of handling the increase in yields. Ammonium sulfate has been the most profitable of the fertilizers tested.

Investigations indicate that nitrogen in the form of ammonia is best suited for lowland rice, whereas most cultivated plants use nitrogen in the form of nitrates. Rice is normally grown on submerged land, which is unfavorable for the formation or retention of nitrates, but some ammonia compounds are formed in and retained by the soil. Applications of non-nitrogenous fertilizers at the Biggs station have failed to increase yields materially. The nitrogenous fertilizers if applied in too great quantity are likely to delay maturity and cause lodging; therefore, they should be used with care.

In fertilizer experiments at Biggs, the largest and most profitable increases in yield for the midseason variety Caloro resulted from applications at seeding time of ammonium sulfate at the rate of 150 pounds to the acre, whereas for the early-maturing variety Colusa (C. I. 1600) [2] they resulted from the application of 200 pounds of ammonium sulfate per acre. The application of ammonium sulfate on the soil surface at the rate of 150 to 200 pounds at seeding time is a common practice. Under certain conditions higher rates of application may be required and are used. When it is impossible to apply ammonium sulfate before or at seeding time, almost as good results are obtained from airplane applications on the field when the rice is in the tillering stage, or up to 65 days after seeding.

WATER SUPPLY

The Sacramento and Feather Rivers, which are fed by melting snows in the Sierra Nevada, supply most of the water used for rice irrigation in the Sacramento Valley. Private and cooperative companies divert the water from these rivers by gravity or by large pumps. The water is distributed to the growers by a system of canals and laterals and sold on an acre-foot basis or at an annual charge per acre.

Very little rice is irrigated from wells in the Sacramento Valley,

[2] The accession number of the Division of Cereal Crops and Diseases.

but in the San Joaquin Valley wells are often the only source of water. Deep wells are expensive to dig, equip, and operate, and should not be depended upon for rice irrigation until they have been thoroughly tested. If wells are to be used they should be ready to operate before the rice is sown. In California, water must be held continuously on old riceland after broadcast seeding on the water or on the surface of the soil. On new land, where the seed occasionally is sown with a grain drill, water is applied to germinate the seed and maintain suitable moisture conditions for growth until the seedlings are large enough to withstand continuous submergence.

PREPARATION OF LAND FOR IRRIGATION

Most of the land on which rice is grown in California is comparatively level, with a gentle slope ranging from 2 to 5 feet per mile. Such land can be prepared for rice irrigation at a reasonable cost. A competent surveyor should be employed to locate the supply ditches, drainage ditches, and field levees. Improper location of these ditches and levees often causes serious losses. Supply ditches should be large enough to furnish ample water when needed. The drainage system should be adequate to dispose of the water promptly. The usual method of connecting the various points on a contour line is to follow the rodman with a plow, the plowed furrow indicating the base of the levee. A tractor drawing 6 to 12 plows makes one round, turning the soil toward the furrow made by the plow. This provides loose ground for building the levees. Sharp turns in levees should be avoided when possible; they make the levees hard to build and harvest more difficult.

The outside levees should be well constructed and higher than the field levees to avoid seepage and loss by overflowing. The outside levees often serve as one bank of the supply or drainage ditch and when so used are often built with draglines, bulldozers, or rotary or Fresno scrapers. The interior, or field, levees are usually made with a checker drawn by one or two tractors, depending upon the size of the checker or of the tractors used. Factory and custom-built checkers are equipped with a device for raising or lowering the rear end, which enables the operators to lift it when moving from levee to levee and in a measure to control the size of the levee. When the ground is rough or trashy the checkers are often weighted so that they will push enough soil together to form a good levee. On large fields these outfits can build from 10 to 15 miles of levees in a day.

The checkers are often home-made and of various sizes. The runners for the sides usually are made of 3- by 12-inch planks, 16 to 24 feet long, and are faced with steel. The front end is from 10 to 18 feet wide on the bottom, and the rear end is 3 to 6 feet wide on the bottom. The sides are 2 to 3 feet high. A tractor-drawn checker is shown in figure 3.

More power is needed to pull a large checker than a small one, but the levees constructed by a large checker are much more serviceable and economical than those poorly built with a small checker. Poorly constructed levees that will not hold sufficient water often result in low yields of rice of poor quality. Levees on small fields are often built with a ditcher, V-crowder, or terracer.

891938°—50——2

Figure 3.—Constructing levees in a California rice field.

The checkers are pulled with the wide end forward, the loose, plowed surface soil being drawn through to the small end. This makes a levee from 18 to 24 inches high and from 4 to 6 feet wide at the base.

It is impossible to connect the field levees and outside levees with the tractor and checker, owing to the space needed for turning. Therefore, the ends of the field levees must be built to connect with the outside levees by using a Fresno scraper, a tractor scraper, or a bulldozer.

Levees on fallow land that have been "knocked down" are sometimes rebuilt in the fall. The winter rains settle these levees and they are in good condition to hold water the next spring.

Boxes at convenient places in the levees facilitate irrigation. The boxes should be placed deep enough so that the bottom boards will not hold the water back when the fields are draining. The depth of water is controlled by shutters held in a vertical position across the

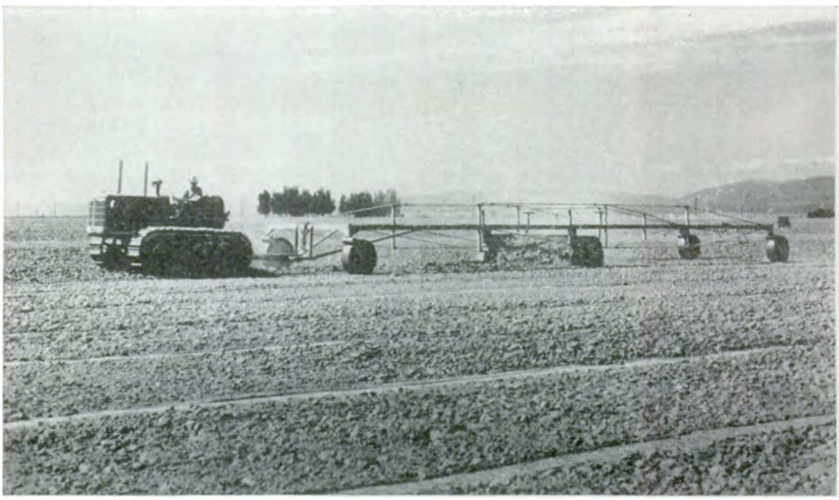

Figure 4.—A large land plane in operation.

openings of the irrigation boxes. By taking out or putting in a narrow board shutter the water can be lowered or raised as desired.

Leveling riceland is now a common practice in California. Land planes (fig. 4) and carry-alls are used in leveling fallow land during the summer and early fall—the slack season between seeding and harvesting. The land is surveyed after leveling, and new levee bases and surface drainage ditches are constructed. Gently curving levees provide for easy manipulation of heavy harvesting equipment and also for a uniform depth of water on the land, which results in better weed control, more uniform stands, even growth, and uniform heading and ripening of the rice. Where high spots are removed to fill in low places, the crop on the fills may grow rank and not mature well the first year, and growth on the scraped places will be somewhat stunted. But such effects are usually temporary.

On old riceland an unequal depth of submergence in the check may not materially affect the date of maturity of the crop, but on new land such inequalities may result in uneven ripening and in grain of inferior quality.

SEEDBED PREPARATION

In preparing the seedbed the land should be spring-plowed 4 to 6 inches deep as early as it can be worked to advantage (fig. 5). After

Figure 5.—Plowing riceland in California.

plowing, the land may be disked, harrowed, or dragged with a heavy float (fig. 6). If the land is very cloddy, it is often dragged two or three times. Disking and harrowing are often omitted; the clods are crushed with heavy drags or clod mashers. The time that elapses between plowing and the other cultural operations gives an opportunity to reduce the clods by weathering; in fact, the action of alternate wetting and drying on clods during these intervals is often more effective than cultivation in preparing a good seedbed. A light rain followed by a few warm days helps to reduce clods.

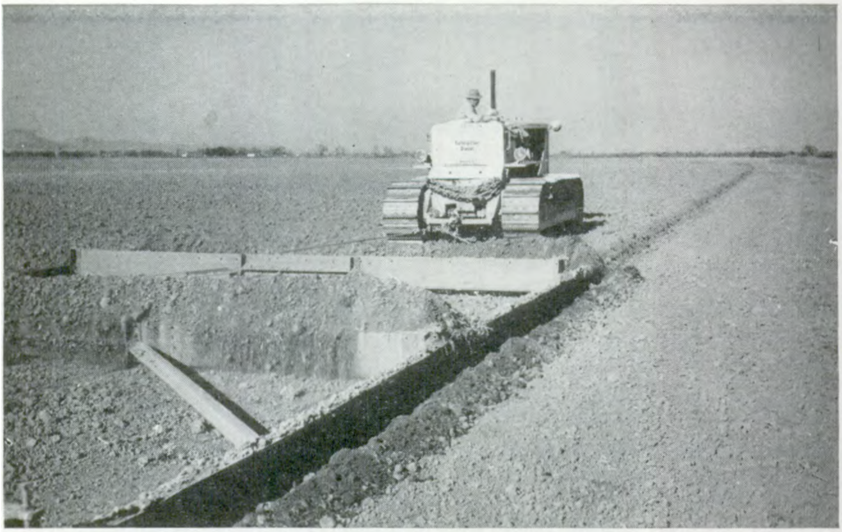

Figure 6.—A heavy float (drag) used in preparing a seedbed for rice in California.

Very little California riceland is fall-plowed, because rice is harvested in October and November, and rain may fall before harvesting is completed and the land can be plowed. In exceptionally dry years some riceland is fall-plowed. The land is easily reduced to a good seedbed by the following spring through the action of rain and sun during the winter. On the other hand, weeds start to grow during the late winter and early spring and are difficult to kill unless the land is replowed shallow in the spring, which makes seedbed preparation expensive. If weed growth is killed on fall-plowed land before sowing, the cost of preparing a seedbed on spring-plowed and on fall-plowed land is about the same. Yields at the Biggs station have been similar on fall- and spring-plowed land.

A slightly rough seedbed is preferable to one that is finely pulverized. The clods slack rapidly after the field is submerged, usually before the seed is sown on the water from an airplane. Large clods, however, may slack down after seeding and bury some of the seeds. When the rice is sown broadcast and then submerged continuously, the seedbed should be somewhat finer and more mellow than is necessary when sowing on the water. Fine pulverization of the soil is not advantageous, and fine soil tends to run together too much after the field is submerged and thus retards germination.

Rice sown on disked stubble does not yield so well as that on plowed land. The disked stubble land provides poorer control of cattails, spike rush, umbrella plants, and other weeds. Skips in a plowed field usually can be detected in the growing crop by the presence of cattails and spike rush (wire grass). It pays to kill all weed growth before sowing rice.

VARIETIES TO GROW

There are two main groups of cultivated rice—glutinous and nonglutinous. The nonglutinous rices are grown most extensively in all rice-producing countries. Based on method of production, there are two general types of rice—lowland (irrigated or rain-fed) and upland. Based on kernel shape and size, varieties of rice are classed in this country as long slender-grain, long-grain, medium-grain, and short-grain (fig. 7).

Most of the commercial varieties grown in California are short-grain (Pearl) rices, and all are of the lowland, or irrigated, nonglutinous type. The short-grain rices of Japanese origin are hardy, yield well, and usually mill well, but the best varieties require a comparatively long growing season. Early-maturing varieties are desirable in California, but in addition to earliness they must have stiff straw and the ability to produce high yields of good milling quality.

Earliness is easy to obtain, but a desirable combination of stiff straw, high yield, and good milling quality with it is hard to find in varieties adapted to California conditions. Earliness in rice, as in most crops, is often associated with low yields and inferior quality.

Varietal experiments at the Biggs station show that the short-grain rices are much better adapted to California conditions than are the medium- or long-grain varieties that have been introduced and tested. Early and midseason short-grain varieties are grown most extensively and produce much higher yields than do the commercial medium- and long-grain rices of the Southern States.

A variety of rice known to be adapted to the section in which it is to be grown is preferable to some new or unknown variety. Sowing a new variety before it has been tested may result in considerable loss to growers. The new variety may not be adapted to the section, may have a weak straw, or may produce low yields of poor quality. Home-grown seed of an adapted variety that is known to produce high yields of good quality is best.

The commercial varieties in California are often mixed as a result of volunteer growth when growers change varieties on land cropped two or more years in succession, and also by airplane seeding and in combines, bank-out beds, dump trucks, driers, and bulk storage bins when a grower produces more than one variety. Such mixtures are undesirable because the varieties usually differ in kernel size and mature on different dates, which usually results in rice of inferior milling quality.

It would probably pay growers to maintain seed plots on their farms on which they could rogue out mixtures and offtype plants. If the crop from such plots is carefully threshed, cleaned, and stored, growers can produce their own seed of a known variety of good quality free of mixtures. Growers who do not wish to raise their own seed usually can buy certified seed produced under the supervision of the California Crop Improvement Association. It is discouraging to see an improved variety, the development of which has cost a good deal of time and money, become badly mixed after being grown commercially for only 2 or 3 years.

The leading varieties of rice in California are Caloro, Colusa, Onsen, Calady, Calady 40, Conway, and Calrose.

CALORO

Caloro was developed at the Biggs Rice Field Station and was first distributed in 1921. It is the leading variety grown in California.

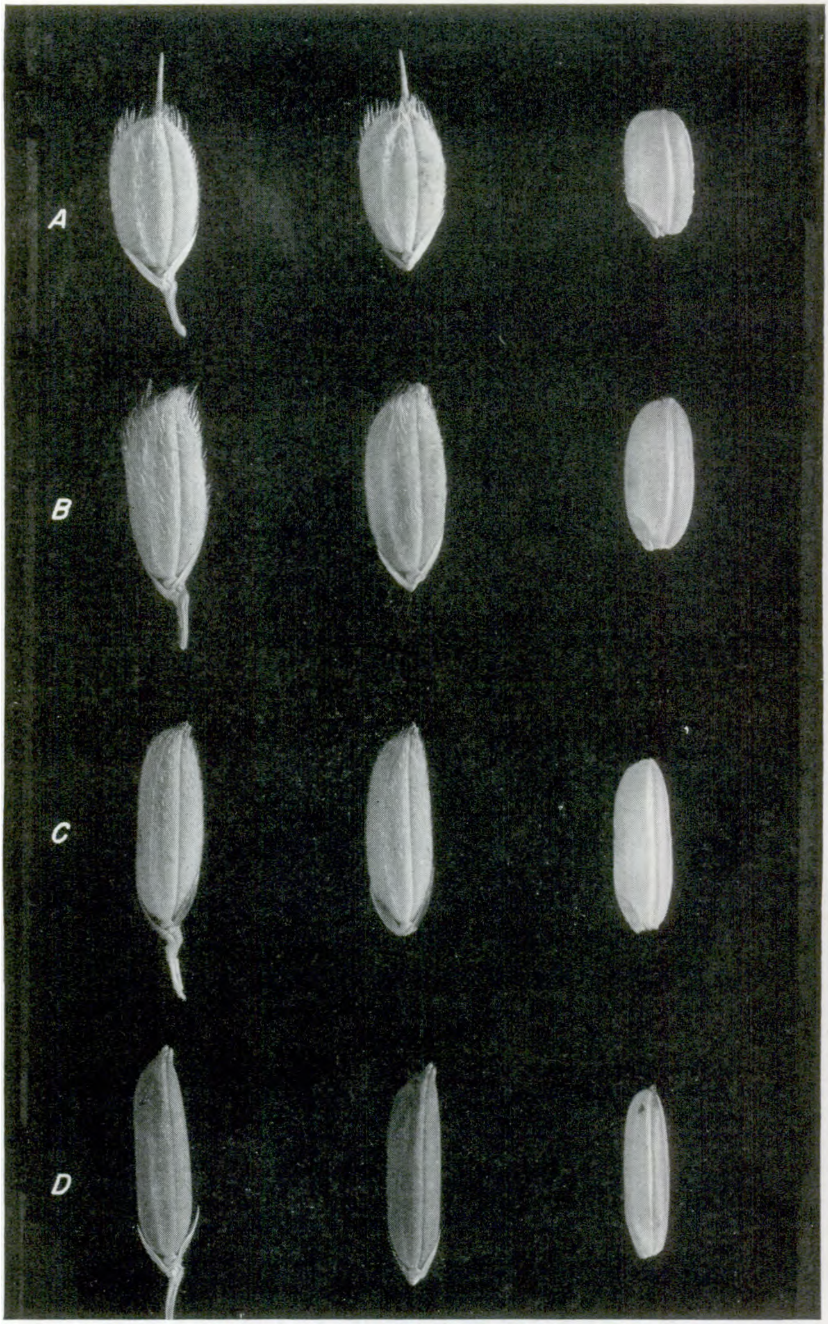

***Figure 7.*—Spikelet, seed, and kernel of (*A*) Caloro, short-grain rice; (*B*) Blue Rose, medium-grain rice; (C) Fortuna, long-grain rice; and (*D*) Rexoro, long slender-grain rice.**

It heads and ripens uniformly and yields well on both new and old land. It matures about 10 days earlier than Wataribune. The grains are short and broad and, like those of Wataribune, have some short yellowish awns (beards), many of which usually drop during harvesting and threshing. Caloro heads rapidly, ripens evenly, and usually yields better than Colusa or Onsen. On old riceland Caloro requires about 155 days from seeding to maturity. In 1949, Caloro was grown on about 80 percent of the California rice acreage.

COLUSA

The Colusa variety (C. I. 1600) is an early, short-grain rice distributed by the Biggs station. It was developed from a selection originally made at the Crowley Rice Experiment Station, Crowley, La. Colusa is 10 days to 2 weeks earlier than Caloro, requiring about 135 days from seeding to maturity on old riceland. It yields well only on relatively fertile land, but is inclined to lodge if the land is very rich. The grains are short and broad, light yellow, and awnless. In 1949 Colusa was the most important early-maturing variety and was grown on about 15 percent of the California acreage.

ONSEN

The Onsen variety is an early short-grain rice introduced from Japan by a Japanese grower in 1918. Onsen is about 2 weeks earlier than Caloro and yields well on new land, but has a marked tendency to lodge. On old land Onsen does not, as a rule, yield as well as Caloro, and requires about 138 days from seeding to maturity. However, it appears to be better adapted in some sections than Colusa. Onsen is not a pure-line variety but is mixed. Most of the crop is very similar to Colusa, though the grains may be slightly larger. They are short and broad, mostly awnless, and the hull is light yellow.

CALADY

Calady, a medium-grain variety, was selected from a cross between Caloro, a short-grain, and Lady Wright, a long-grain variety, at the Biggs station. Seed of Calady was distributed to farmers in the spring of 1934, but it yielded less than Caloro and was not popular with growers, though of very good milling quality.

CALADY 40

In the fall of 1935 a number of panicle selections were made from commercial fields of Calady. These selections were grown in the nursery at the Biggs station in 1936. One of them was much more vigorous than Calady. Later named Calady 40, it was increased and tested for yield in nursery and field plots at Biggs. It was first grown on a field scale in 1940, and was distributed to farmers in the spring of 1941. Calady 40 is a stiff-strawed, partly awned, medium-grain variety that is, on lands of average productivity, resistant to lodging and shattering. It is harder to thresh than Caloro and for this reason is somewhat more difficult to combine. The heads of Calady 40 are compact and have a tendency to produce at the base of the heads a cluster of seed that does not always mature properly. It matures about 4 days later than Caloro and in tests has yielded as well as or better than Caloro, but it is not satisfactory to growers. The milled rice of Calady 40 is attractive, for the kernels are usually hard and translucent and of as good or better cooking quality than Caloro.

CONWAY

Conway is an early-maturing, awnless, short-grain variety selected from the Haya Kitabu variety introduced from Japan in 1926. It matures about a week later than Colusa and about a week earlier than Caloro. Conway has slightly shorter straw, matures more evenly than Colusa, and is less inclined to lodge. It is equal to Colusa in yielding capacity and is of better milling quality than either Colusa or Caloro. Seed of Conway was distributed to a few growers for field trials in 1947. It should, under average conditions, yield as well as Colusa. Conway is much more difficult to combine than Colusa or Caloro, and for this reason it is grown on only a small acreage.

CALROSE

Calrose was developed by selection at the Biggs station from the cross Caloro × Calady backcrossed to Caloro. It is a medium-grain, partly awned variety, identical in growth habit and maturity with Caloro. Yield tests at the Biggs station indicate that it is equal to Caloro in yielding capacity, which is very good. The kernels of Calrose are more transparent than those of Caloro. Calrose stands up well, matures evenly, and is as easy to combine as Caloro. In milling quality it appears to be better than Caloro. Normally, milled rice of such medium-grain types as Blue Rose and Zenith sell at a premium over short-grain (Pearl) varieties. Hence, Calrose might be profitably grown in California for sale in markets that prefer medium- to short-grain rices. Seed of Calrose was increased in 1947 at the Biggs station and distributed to a few growers for trial in 1948. It yielded well in 1949 and will be grown on a much larger acreage in 1950.

SEED

After deciding upon the proper variety to grow, one that is adapted to the locality, has stiff straw, and yields and mills well, it is important to have a supply of good seed. Economy in crop production is desirable, but it is false economy to use poor seed rather than to pay a slightly higher price for good seed. Certified seed of the main rice varieties is in large demand because rough rice of high quality now sells at a premium.

Good seed rice should be graded and cleaned with a fanning mill. It should be free from red, immature, hulled, or broken rice or the seeds of other rice varieties or weeds. Good seed rice should be well filled and uniform in size. Uniformity in size and ripening is more important in rice than in other cereals, because the value of rough rice is largely based upon the percentage of head rice (whole kernels) obtained in milling. Larger yields of head rice are obtained from well-matured rough rice consisting of grains of uniform size of one variety than from immature rough rice consisting of grains of different sizes and a mixture of varieties. Seed rice containing red rice should not be sown, for red rice materially reduces the market value of a crop.

Planting rice seed containing immature, hulled, or cracked grains often results in poor stands that ripen unevenly and produce low acre yields of inferior quality. Grasses and weeds increase the cost of production, reduce yields, and lower the market value of the crop (fig. 8).

Mixtures of varieties that mature at different times and differ in kernel size are very undesirable in rice. The combine-drier method of harvesting and bulk storage results in more mixing of varieties than did the binder-thresher method of harvesting and sack storage. Special precautions are therefore necessary to avoid the mechanical mixing of varieties under modern harvesting methods. To avoid mixing in

Figure 8.—**Seed rice containing weed seeds.**

combining, drying, and storing in bins, it may be advisable to harvest seed rice with a binder or to sack combined rice and dry it in sack driers.

If there is any doubt as to the germination of the seed, it should be tested before it is sown. The State Seed Laboratory, California State Department of Agriculture, at Sacramento, will make germination tests of samples accompanying the request. If seed of rather poor germination must be used, the rate of seeding should be increased materially.

SEEDING

METHOD OF SEEDING

In 1929 a section of land near Merced, Calif., on which the stand of rice was practically destroyed because the seed was eaten by mud hens,

891938°—50——3

was resown on the water by airplane. A fairly good crop was harvested. In 1930 several rice growers who used airplanes to sow rice on the water obtained satisfactory stands and yields (cover and fig. 9).

Figure 9.—**Guided by a flagman, an airplane sows rice seed in an inundated field in California.**

Most of the rice acreage in California is now sown broadcast on the water with airplanes, though some fields are broadcast with endgate seeders before the land is submerged. Broadcasting on the water by planes is rapid and gives a satisfactory distribution of the seed when done by experienced pilots. Rice sown broadcast before the land is submerged should not be harrowed after seeding.

DATE OF SEEDING

The best date to sow rice in California varies with the soil and climatic conditions from year to year. Rice may be sown between April 15 and June 1, but for the best results, with all methods of irrigation and when soil conditions and temperature permit, it should be sown as early as possible. There is less danger of losses from fall rains when the crop is sown early.

Caloro rice has a tendency to mature within a certain period regardless of the date of seeding, but all varieties usually give higher yields when seeded early.

Light soils are warmer early in the spring than heavy soils; hence seeding may be earlier. Rice sown on a cold soil and irrigated with cold water during a period of low temperatures usually germinates slowly, and often 3 weeks elapse before the plants emerge. Under such circumstances seeding should perhaps be deferred until conditions are more favorable for germination and growth. Under California's variable conditions no best date of seeding can be recommended. However, the commercial varieties now grown should be sown as early as weather and soil conditions permit, from April 15 to May 10.

The results at Biggs indicate that stands of rice obtained by seeding 130 to 140 pounds on the water are as good as those from 150 pounds seeded on the surface of the soil. If the stands are good, the yields from both methods of seeding are about the same. Seeding on the water, though slightly more expensive than seeding on the surface of the soil, is now the standard practice. The reasons for this are: Less seed is required; the possibilities of getting good stands of rice are better because less seed is covered with soil; the seed is protected from birds; and less labor is required to prepare a seedbed, because the water slacks the clods. When the seed is sown on the surface of the soil the clods should be reduced as much as possible before seeding to keep the seed from being too deeply covered by slacked clods.

Many growers now soak sacked seed rice for 36 to 48 hours in canals or tanks and hold the soaked seed for 12 to 24 hours to induce partial germination before seeding on the water. Soaked seed sinks promptly when it is broadcast on the water; hence, drifting of floating seed is prevented and more uniform stands are obtained.

Early and midseason varieties should be sown at the rate of 140 to 160 pounds per acre on land to be continuously submerged and 130 to 150 pounds per acre when sown on the water.

IRRIGATION [3]

The continuous submergence method of irrigation is the common practice in California. When the rice is sown on the surface of the soil, the fields are immediately submerged from 4 to 8 inches deep and the water is held continuously at this depth until the crop is nearly ready to drain for harvest. When rice is sown broadcast on the water, only shallow water (2 to 4 inches deep) is held until seeding is completed. Then the depth of water is increased to 4 to 8 inches and

[3] See U. S. Dept. Agr. Farmers' Bulletin 1240 for additional information of previous methods of irrigation. Available in libraries only.

the water is held continuously at this depth until the land is ready to drain for harvest, except for special reasons. The continuous submergence of rice sown broadcast on the surface of the soil or on the water is very effective in controlling the growth of the early and midseason types of water grass.

When the land is submerged at the same depth there is no difference in the control of water grass, whether the rice is sown on the surface of the soil and immediately submerged or whether it is sown on the water. On rough seedbeds, and on smooth seedbeds to a certain extent, the submergence of the land after seeding often slacks enough clods to cover part of the rice seed. This is an important factor, for, as previously noted, rice seed covered with soil and water does not germinate well. The supply of oxygen under such conditions seems to be too low to initiate normal root development. Rice seeds covered with soil and water often rot, though some may germinate, producing long, bleached plumules (leaves) without root systems. These seedlings are unable to emerge to the surface of the soil and water. Rice sown broadcast on the water is seldom covered with soil, for the clods are slacked and the surface of the soil is leveled by the water before the seed is sown. After seeding on the water strong winds may cause the water to wave, and this movement often covers some of the seed with a thin layer of fine soil particles. However, this seldom buries the seeds too deep for normal germination and root development.

In preparing a seedbed on land that is to be continuously submerged, all organic matter should be plowed under. Organic matter left on the surface of the soil decomposes in and under water, and if a large quantity of such material is present it may, and often does, discolor the water. To a certain extent discolored water keeps the sunlight from reaching the submerged seedlings. A lack of sunlight results in weak seedlings, many of which are unable to emerge to the surface of the water, and thus poor stands are obtained. Relatively clear water is helpful in obtaining vigorous seedlings and good stands.

Scum, which appears to consist of various kinds of algal growth and partly decomposed organic particles, often prevents emergence of the rice seedlings to the surface of the water. It is less troublesome on well-drained land free of vegetation than on poorly drained land. Ordinarily, scum does not develop nearly so fast at low as at high temperatures. Therefore, as a rule, rice should be sown as early as possible in the spring, so that the seedlings can emerge through the water before scum develops.

The formation of scum and discolored water are important factors in the control of water grass. Young water grass seedlings under water grow more slowly than rice seedlings. The rice seedlings, therefore, emerge to the surface of the water in a shorter time than the grass seedlings. The grass seedlings often become coated with fine particles floating in the water, which keep them from emerging to the surface, so that they die.

Young water grass seedlings submerged in clear water will live for weeks, even at high temperatures, but as soon as scum develops on the water they bleach out, become weak, and die.

If sunlight, which furnishes the energy for growth in green plants, is reduced by scum, discolored water, or shade, seedlings under water are weakened and eventually die. Rain, for some unknown reason, causes scum to settle to the bottom. If seedlings of either rice or weeds are under the scum, they usually fail to emerge.

When the land is submerged, water flows from one check to another, and normally there is little danger that any part of the field will become stagnant if the water is maintained at a constant depth. Therefore, it is not necessary, on lands that are free from alkali, to have water overflowing the last check into a drainage ditch.

Good irrigators appreciate the value of water and do not waste it. Basing water charges on the volume delivered rather than charging a flat rate per acre would tend to conserve water and to confine rice growing to the heavy soils, on which from 4 to 8 acre-feet of water are required to produce a crop.

Profitable rice crops cannot be grown in California without submerging the land continuously for 90 to 140 days (fig. 10). Rice grown on land kept moist, but not submerged, is dwarfed and produces small heads and low yields of poor quality.

Figure 10.—**Field of rice in California.**

DRAINAGE

The importance of good drainage should not be underestimated in rice production. Poorly drained land is usually expensive and difficult to cultivate and seldom produces maximum yields. Weeds, such as cattails, umbrella plants, spike rush, water lillies, smartweed, and grasses, are difficult to control. Harvesting is usually more expensive, and shattering and lodging of overripe grain often cause losses. Before the rice is sown or irrigated it is advisable to provide drainage for the law places in the field.

Good judgment is essential in deciding when the rice crop is ready to drain for harvest. No set rule for the time to drain can be given, because so many factors must be considered. Some soils dry quickly after draining, others very slowly. It is evident, therefore, that the water should be held longer on soils that dry quickly than on those that dry slowly. As a rule, heavy soils dry slowly, but they crust or bake at the surface much more quickly than light soils. For this reason, some light soils should be drained earlier than heavy soils; they need more time to form a crust at the surface to support harvesting machinery. The weather has a marked influence upon the date of draining. It usually takes from 10 to 18 days after draining for the land to be dry enough to support harvesting machinery. The levees should be cut in many places so that all land can be drained from the low spots in the field.

No water should be allowed to enter the fields for about a week prior to draining the land for harvest. This gradual lowering of the water is desirable because rapid draining tends to cause lodging. Large quantities of drainage water also may damage crops on lower lands.

Rice should be drained early enough to permit the ground to become firm, so that it will support harvesting machinery by the time the crop is practically mature. It is usually ready to drain when the panicles are well turned down and the lower grains on the panicles are in the soft-dough stage. At this time the upper two-thirds of the grains on the panicles are usually turning yellowish.

Rice of the varieties grown in California requires about 45 days from first heading to maturity. About 10 days elapse from the time the first panicles appear until the crop is fully headed.

After the rice panicles are well turned down, they seem to mature as well in shallow as in deep water. When rice is drained too early the yield is reduced and some grains are immature, resulting in inferior milling quality. When drained too late overripeness often causes a loss, with resulting shattering during harvest and possible lowering of milling quality due to checking.

Some rice probably is damaged in California each year as a result of draining too early or too late. Rice drained at the right time is ready to harvest before it is overripe and yet is not immature. At this stage it yields and mills best.

Drainage ditches should be cleaned during the slack season prior to draining for harvest, so that the fields can be drained promptly when necessary.

Harvesting in the mud will soon discourage even an optimist and will materially reduce the profits of a crop that otherwise would be very profitable.

For many years little attention was given to the drainage problem, but now drainage districts have been organized and surface drainage systems have been greatly improved in all areas.

Drains should be kept open during winter. This prevents waterlogging and the possible accumulation of alkali salts in the surface soil when it dries. Good drainage also aids in the aeration of the soil, which is distinctly beneficial to ricelands.

HARVESTING

Rice is ready to harvest usually from 10 to 18 days after draining. At this time the panicles should be well turned down and yellowish, and the lower grains on the panicles should be in the hard-dough stage. At this stage of maturity the moisture content of the standing grain ranges from 20 to 27 percent. If harvested before this stage of development, the milling quality is lowered and the yields are reduced by the presence of immature chalky kernels. If harvested with less than 20 percent of moisture, there may be a loss from shattering and from inferior milling quality due to checking.

The rice crop is largely harvested with tractor-drawn and self-propelled combines (figs. 11 and 12). Push swathers and self-propelled combines are used in opening up, or cutting, the first swath against the levees. These methods save considerable rice, for, in California, each check (land enclosed by the same levees) is harvested separately. The windrow, placed on the stubble by the swather, is immediately threshed with a combine equipped with a pick-up attachment. Tractor-drawn and self-propelled combines then harvest the rest of the check. Factory and custom-built self-propelled and tractor-drawn combines, mounted on crawler-tracks or rubber tires, with cuts ranging from 6 to 20 feet, are used. The moisture content of the combined rice is reduced gradually to 14 or 15 percent in artificial driers, and the dried rice is stored in bulk or sacks.

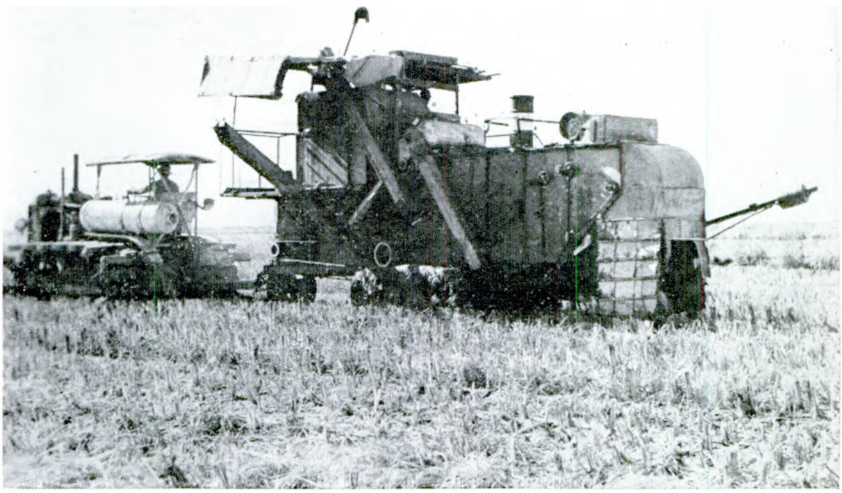

Figure 11.—Harvesting rice in California with a tractor-drawn combine.

Custom-built combines generally consist of a stationary rice thresher of relatively large separating capacity, mounted on crawler tracks. The power for cutting, threshing, and elevating operations is supplied

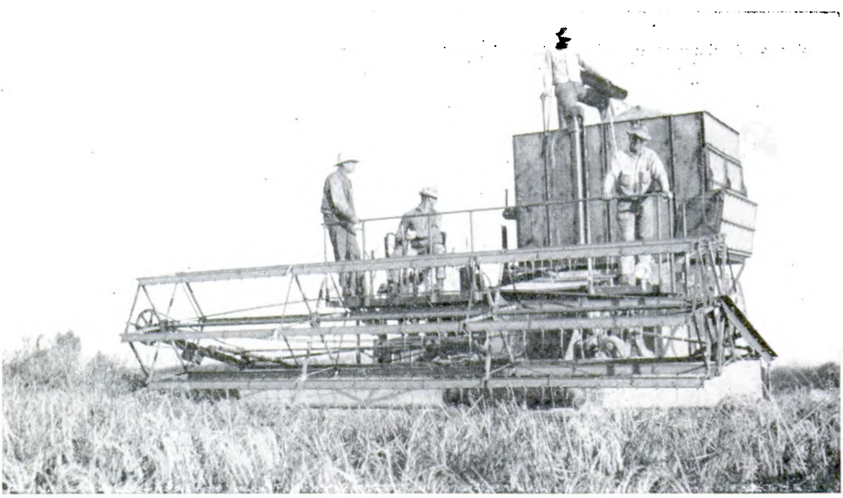

Figure 12.—**Harvesting rice in California with a large, custom-built self-propelled combine.**

by an auxiliary engine. These combines are said to be more efficient than most commercial machines for harvesting heavy crops of standing or lodged rice.

The combined rice is elevated into a bin or hopper on the combine. When the bin is full the rice, if the ground is firm, is emptied or augered into a dump truck and hauled directly to the drier. On soft land the bin is emptied into a bank-out bed, usually mounted on a crawler track and drawn by a tractor that hauls the rice to firm ground (fig. 13). The sides of the bank-out bed slope gradually to the bottom. Lengthwise at the bottom or at the rear end of the bed is a conveyor

Figure 13.—**Transferring rice into a bank-out bed from a combine.**

driven by a power take-off from the tractor that elevates the rice into dump trucks which deliver it to the drier (fig. 14).

At the drier (fig. 15) the rice is dumped into a hopper and elevated to the top of the drier, where it passes through cleaning equipment

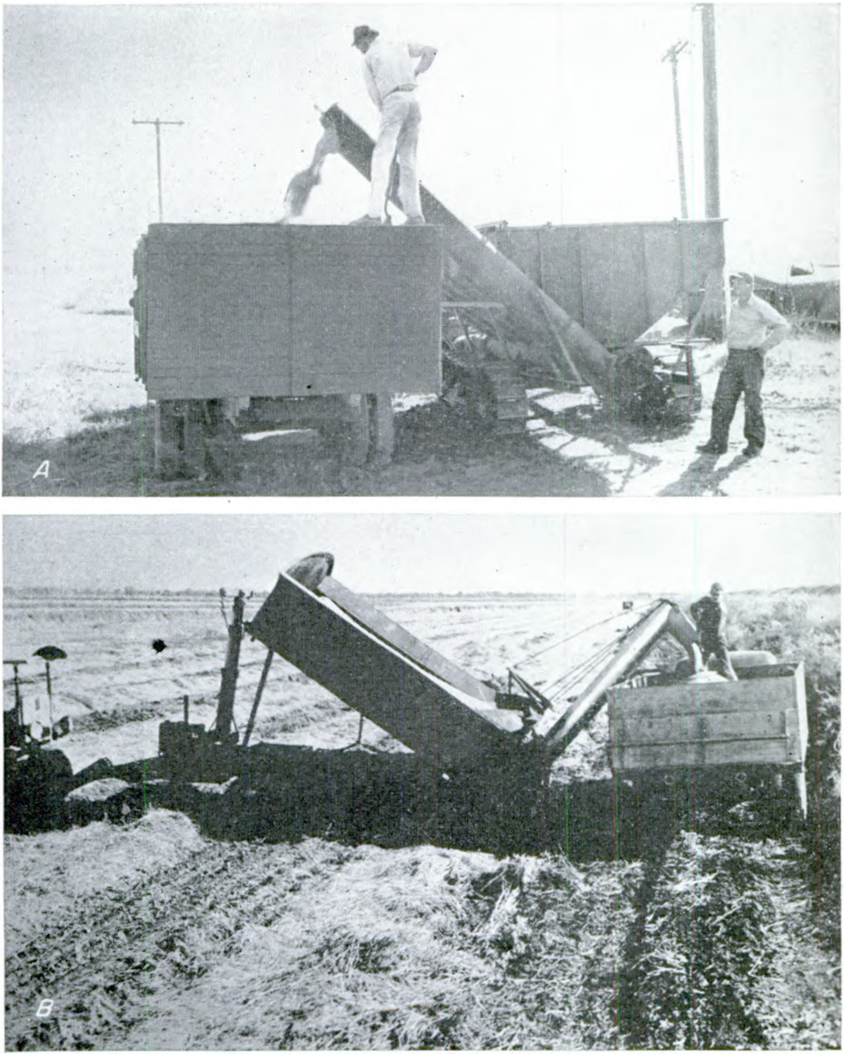

Figure 14.—Unloading rice from a bank-out bed into a dump truck: *(A)* With conveyor lengthwise at the bottom of the bed; *(B)* with conveyor at the rear end of the bed.

into hoppers, or bins, from which it passes by gravity or by conveyors into the drier stands. Warm air, usually ranging in temperature from 100° to 115° F., forced through the columns of rice as it moves down through the drier stands, gradually reduces the moisture content of the grain. It is customary to pass the rice through the drier two to four times, so that it will dry gradually without injury to milling quality. The period between passes through the drier usually ranges from 12 to 36 hours. Between runs the moisture content of the partly dried grain stored in bins is equalized, thus facilitating drying. The dried rice is stored in bulk bins in elevators and warehouses (fig. 16).

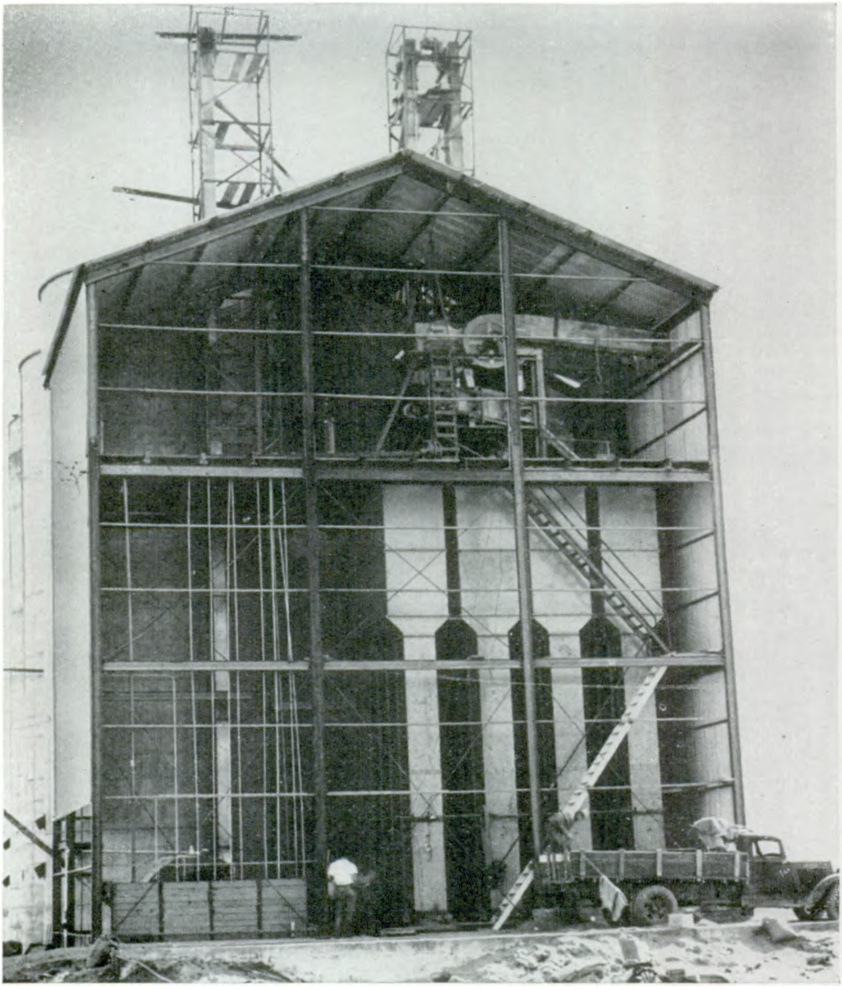

Figure 15.—**Unloading rice at a modern rice drier. The building, the front wall of which has not yet been completed, has four drying units, with elevators to convey the rice to and from them. Above the drying units is the cleaning machinery. A fan (lower left) forces the warm air into the driers.**

Some rice each year is cut with 12- to 14-foot swathers and permitted to dry in the windrow for 3 to 6 days. Then it is threshed with combines equipped with pick-up attachments (fig. 17). This method was used extensively between 1930 and 1935. Drying in the windrow often is uneven and rice handled in this manner is usually of poorer milling quality than that combined direct and dried artificially. Artificial drying is not necessary with this method of har-

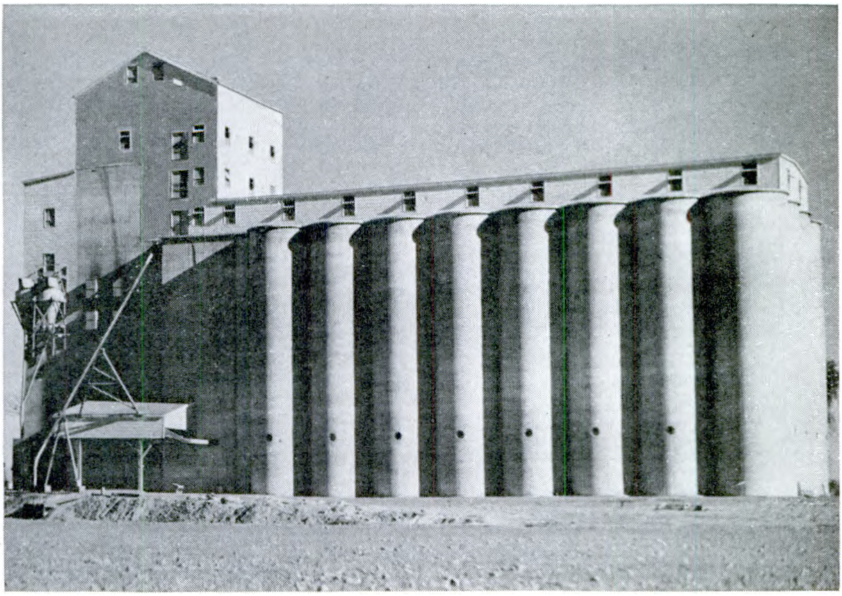

Figure 16.—**Modern elevator for bulk storage of rice.**

vesting; but the rice is exposed to weather hazards while drying in the windrow, whereas rice combined direct is immediately placed under cover.

The small acreage harvested with binders is shocked promptly and permitted to dry in the shock (fig. 18) for 7 to 14 days; then it is threshed with a stationary thresher, sacked, and stored (fig. 19).

Figure 17.—**Threshing rice from the swath in California with a combine with pick-up attachment.**

Figure 18.—**A field of shocked rice in California.**

Figure 19.—**Threshing rice with a stationary thresher equipped with an aspirator, which is removing material from the grain (left).**

WEEDS

Weeds are a menace to rice production in California. Most of the land in rice is infested with these pests, which materially decrease yields if not controlled. Plants that inhabit wet places find conditions in the rice fields ideal for their development. Most of these plants have the characteristic weed habits—hardiness, abundant seed production, and shattering—which make them difficult to control or eradicate.

Weeds increase the cost of production and reduce yields. Weed seed mixed with threshed grain lower its price.

Seed rice containing weed seeds should not be sown. Troublesome weeds should not be allowed to grow along canal banks or in waste places. Animals pastured on foul land should not be transferred to clean land. Combines should be well cleaned before moving from a weedy to a weed-free farm or field. When only a few weeds appear on the roads, levees, ditch banks, and in the field, they should be pulled by hand or mowed before they mature seed.

The following paragraphs are quoted from page 223 of the California Department of Agriculture Twenty-eighth Annual Report, 1947:

"Spraying California rice fields for weed control has become a major operation. It is estimated that 100,000 acres were sprayed in 1947, as compared to 8,000 in 1946.

"In 1947 the most prevalent water weeds in rice fields, exclusive of the grass family were arrowhead lily (*Sagittaria* spp.), waterplantain (*Alisma* spp.), redstem (*Ammannia coccinea*), bulrush (*Scirpus* spp.), sedge (*Cyperus* spp.), and cattail (*Typha* spp.). Two newcomers, not formerly pests, came to the attention of rice growers this season, namely, water hyssop (*Bacopa rotundifolia*) and rough-seed bulrush (*Scirpus mucronatus*). Water hyssop is not sufficiently susceptible to 2,4–D to be amenable to control but rough-seed bulrush responds very satisfactorily.

"Generally speaking, the selective use of 2,4–D in rice has given excellent results, although some dissatisfaction was expressed by growers in the Sacramento Valley, the majority of whom had applied sublethal dosage rates."

On page 229 of the above annual report Margaret K. Bellue states that "*Cyperus difformis* is also currently abundant in the Biggs-Colusa rice fields." Also that "*Scirpus tuberosus* [a bulrush] has persistently resisted efforts at control and has spread alarmingly in one rice field where it has recently become established."

W. A. Harvey and W. W. Robbins,[4] of the California Agricultural Experiment Station, report that "In rice fields, airplane applications of 2,4–D have been successful in control of arrowhead lily, water plantain, burhead, certain sedges, and other water weeds. The usual treatment was 15 gallons per acre of a solution containing 1 to 1½ pounds of 2,4–D [2,4-dichlorophenoxyacetic acid]. (One pound is probably sufficient.) Where the water was low when spray was applied, there was some damage, but fields sprayed when the water was up and the plants well established showed no serious injury."

For information on the proper time, materials, rate, and manner of application of 2,4–D sprays to control weeds, consult your county agent.

The worst weeds in the California rice fields are barnyard and joint grasses, red rice, arrowhead, waterplantain, redstem, umbrella plants, cattails, rushes, and water hyssop.

BARNYARD, OR WATER, GRASSES

Barnyard grasses (*Echinochloa crusgalli* and varieties), which are locally known as water grasses, are the most troublesome weeds in

[4] Harvey, W. A., and Robbins, W. W. 2,4–D as a weed killer. Calif. Agr. Col. Ext. Cir. 133, 12 pp., illus. Revised, 1947.

the California rice fields. There are several varieties of water grass, some bearded and others beardless. These varieties differ considerably in date of maturity, height, and size of stems, heads, and seeds.

The barnyard grasses are annuals that usually tiller abundantly and produce a large number of viable seeds. These grasses are quite widely distributed in the United States and are usually found growing along sloughs, irrigation ditches, drainage ditches, on low land, and in marshy irrigated fields. They are kept under control in the California rice fields by continuous submergence of the land.

RED RICE

Red rice (*Oryza sativa*) is usually present in all rice-producing countries of the world. It is the worst pest in the rice fields of the Southern States and has been introduced into California. Red rice can be detected in seed rice by hulling a sample of the rough rice. Red rice has a red seed coat when the hull is removed, whereas the common rice has a brownish or whitish seed coat. Seed containing red rice should not be sown. The presence of red grains in milled rice reduces its value.

Southern red rice has a spreading habit of growth; the commercial rices grow more erect. The heads of Southern red rice are loose, open, and slightly drooping. The grain shatters readily when ripe, and in this way it spreads very rapidly. The rice growers of California should guard against the spread of this troublesome pest. Seed rice bought outside the State should be examined carefully for red rice before it is sown.

A red rice, locally known as Italian, which is quite different in growth habit and size of kernel from the Southern red rice just described, is found in California rice fields. It matures earlier and has a longer grain than the Southern red rice. Its growth resembles that of the commercial varieties of rice, but the seed shatters more readily. This red rice, like the other, lowers the commercial value of the crop, and seed rice containing it should not be sown.

Red rice can be eradicated in California by using seed free of red rice on fallow land, as there is no evidence that much red-rice seed is viable after a fallow year. If the land is cropped continuously to rice and if seed containing red rice is sown the first year, it will no doubt increase with each successive year. Seed containing red rice is expensive at any price.

ARROWHEAD

Arrowhead (*Sagittaria latifolia*), also locally known as waterlily, is a perennial and probably is present to a larger extent in rice fields on the west side of the Sacramento River than in those on the east side of this stream. During recent years this weed has been spreading in the rice fields. Like waterplantain it also makes a better growth in low places in the fields where the stands of rice are likely to be thin. It is usually rather thick along the edges of sloughs and in the deeper water. Arrowhead is easily identified by the leaves, which are shaped like arrows. Good stands of rice help to check the stand and growth of arrowhead. It is not controlled by continuous submergence. Both waterplantain and arrowhead are serious weed pests.

WATERPLANTAIN

Waterplantain (*Alisma plantago-aquatica*), locally known as waterlily, was confined for several years to the banks and edges of irrigation ditches. During the last few years, however, this weed has been increasing in the rice fields. It emerges through water as well as, or better than, rice; therefore it cannot be controlled by continuous submergence. The seeds of waterplantain are reddish brown and they are reported to be able to remain dormant for years and then germinate under suitable environmental conditions. This weed appears to germinate at lower temperatures than does rice and is often present in large quantities in the intake checks where the cold water enters and the stands of rice often are poor. Good stands of rice help to check the stand and growth of waterplantain, which makes its best growth in thin stands of rice. Means of controlling this weed are germination of the seed by irrigation followed by cultivation, and spraying with 2,4–D.

REDSTEM

Redstem (*Ammannia coccinea*) is found in shallow drainage ditches and along sloughs and is often present in the rice fields, especially where stands are thin. When mature the entire plant above the ground is red in color, hence the name. The plant consists of a single stalk, with the flowers borne in the axils of the leaves. The seeds are produced in a round capsule about the size of a small pea. These capsules are often present in combined rice and, if green, increase the cost of drying rice. The base of the stem under water is covered with a spongelike structure. Good cultivation and spraying with 2,4–D will doubtless control redstem.

UMBRELLA PLANTS

Several umbrella plants (*Cyperus* spp.), commonly known as sedges, grow in the rice fields. The perennial forms grow on the levees and ditch banks and on poorly drained abandoned land. These forms are not troublesome on well-drained land properly cultivated. On poorly prepared seedbeds the perennial forms enter the checks, but improved drainage and good cultivation will help rid the fields of them.

The annual form (*Cyperus difformis*) is found most abundantly in the rice checks. It does not make its appearance until after the land has been submerged for some time. It appears in abundance where stands of rice are thin, and sometimes in good stands. The plants grow from 6 to 18 inches high, and a thick stand of them checks the growth of rice. No cultural method of control is known for this weed, since it appears on good and on poorly drained land, on good and on poor seedbeds, and in thick and in thin stands, but it is usually thickest where the stands of rice are thin. It is most troublesome in seasons preceded by very wet spring weather. It apparently is rather difficult to control by spraying with 2,4–D.

BULRUSH

Recently Margaret K. Bellue [5] reported that the rough-seed bulrush (*Scirpus mucronatus*), a native of the Old World and of wide distribution in Europe, is present on an estimated 10,000 acres of riceland in northern California, principally in the Cordora section of Glenn County, and in the vicinity of Gridley, Biggs, and Richvale in Butte County. This weed produces numerous tuberlike rootstocks and viable seed. It can therefore spread rapidly.

SPIKE RUSH

The spike rush (*Eleocharis palustris*), locally known as wire grass, grows on poorly drained land, in shallow ditches, and on field levees and establishes itself in rice fields in the corners of checks and elsewhere where cultivation and drainage are usually poor. The spike rush is a leafless perennial plant that produces seeds at the tapering end of a single round stem. The stems vary in diameter from one-sixteenth to one-eighth of an inch. The spike rush spreads by means of underground rootstocks. It will completely crowd out a good stand of rice, and the crop cannot grow where the spike rush is well established. Good plowing, deep enough to get under the roots and turn them over, followed by thorough drying, is very effective in the control of this weed. The spike rush usually is not troublesome on land that is reasonably well drained and properly cultivated. Its presence in rice fields often indicates poor seedbed preparation, poor cultural methods, or poor drainage.

CATTAILS

Cattails (*Typha latifolia*), locally known as tules, grow in sloughs and drainage ditches, on poorly drained land, and in rice fields. The cattail is a perennial that spreads by seeds and creeping rootstocks. The cylindrical head of the cattail, which ranges in length from 6 to 12 inches, is borne at the end of a round stalk. Each head contains thousands of seeds, which are readily spread by wind and water. Deep moldboard plowing followed by thorough drying of the soil is very helpful in the control of cattails. Good stands of rice have a tendency to prevent cattails from entering a field. They usually appear first in low spots or along the levees where the soil has not been well cultivated and stands of rice are poor. Disking rice stubble instead of plowing it in preparing the seedbed for rice provides favorable conditions for the growth of cattails and other weeds. Good seedbed preparation pays, if for no other reason than that it helps to control cattails. Cattails are somewhat susceptible to 2,4–D, though not easily controlled by spraying.

WATER HYSSOP

Water hyssop (*Bacopa rotundifolia*) is an annual plant that looks very much like water cress. In thin stands of rice water hyssop is often quite thick, and under such conditions it appears to retard the development of the rice plants. This weed, however, blooms early in

[5] BELLUE, M. K. ROUGH-SEED BULRUSH, SCIRPUS MUCRONATUS L. A MENACE TO RICE PRODUCTION. Calif. Dept. Agr. Bul. 36: 91–96, illus. 1947.

the season, and when the water warms up it usually dies and the plants rot and disappear. It does not appear to be a serious weed pest except that it may check the growth of rice early in the season.

JOINT GRASS

Joint grass (*Paspalum distichum*) is an obnoxious perennial weed pest in the irrigation ditches and often spreads into the rice checks. It is a creeping grass that spreads rapidly by rooting at the joints, or nodes. Runners from this grass may extend from the levees into a rice check for a distance of 25 feet or more, and it will grow on submerged land. It is difficult to eradicate, for it is able to withstand drought or water. Joint grass is very troublesome in irrigation ditches because of the dense growth that partially dams up the ditches unless they are frequently cleaned. It is spread by seed and sections of plants that may be carried by implements or that may float in the water. Frequent cultivation during a fallow season may be helpful in controlling this grass.

INSECTS AND OTHER PESTS

California rice fields have always been singularly free from insect enemies. None of the insects of major importance that injure rice in Louisiana, Arkansas, and Texas have been found in California fields. Grasshoppers of several species have been found feeding upon the rice leaves and the culms. The western 12-spotted cucumber beetle (*Diabrotica soror* Lec.) has also been observed in large numbers feeding on leaves and on the grain, but most of the individuals of this species seem to prefer rice pollen to other food. Leaf hoppers, flea beetles, and leaf tiers have also to a small extent been found feeding on rice. None of the pests discovered thus far have been known to cause serious damage to the rice crop. The main problem in California, therefore, is to prevent the injurious rice insects in other parts of the United States and in foreign rice-growing countries from entering the rice fields of that State.

When injury is observed and information is desired, specimens of the insect causing the damage, together with a sample of the injured plant, should be sent either to the State experiment station or to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C.

Blackbirds are troublesome in rice fields in the spring and fall. In the spring large flocks of blackbirds pick up the rice after broadcasting and before the land is submerged. The crops of a number of blackbirds shot in the spring of 1922 contained from 4 to 48 kernels of rice each. They no doubt consume a good deal of rice and may help to cause thin stands. They also damage the rice after heading, when it is in the milk stage. Keeping the blackbirds away by shooting early in the morning and in the evening when they usually feed should be helpful.

In mature rice fields with open water, wild ducks often cause serious damage. They alight in the open water and feed out into the rice checks. Small planes are being used to herd and prevent wild ducks from damaging the matured rice crop before it is harvested. Mud hens (coots) have been rather troublesome in the rice area. These birds alight in the open water after seeding and feed upon the soaked seed rice. They are accused of pulling up the poorly anchored seedlings following germination. Once they become established it is practically impossible to drive these birds from a field. Just how much damage they do to the stands of rice is difficult to determine.

All of these bird problems are being investigated by a representative of the Fish and Wildlife Service, Department of the Interior, at Marysville, Calif., with whom interested rice growers should communicate.

The tadpole shrimp (*Apus oryzaphagus* and *A. biggsi*) is not an insect but a member of the family Crustacean. This shrimp was first noted as a pest in California rice fields in Butte and Sutter Counties in 1946. In 1947 and 1948, they were present on a larger acreage and may eventually spread over the entire rice area.

The tadpole shrimp injures rice seedlings by (1) chewing the leaves, stems, and roots of young plants before they emerge through the water, (2) digging in the soft mud and dislodging plants, which float to the surface of the water, and (3) keeping the water muddy, which excludes sunlight and prevents weak seedlings from emerging. Tadpole shrimp eggs laid the previous year hatch in from 5 to 7 days after the land is submerged, and in another 5 to 7 days the young shrimp have become active and cause the water to be muddy. At this stage, rice seedlings are very susceptible to damage. The adult shrimps may be present in only a few checks in a field or distributed over an entire field. They may be confined to the lower checks or to low areas in the field.

The tadpole shrimp can be controlled by applying copper sulfate (bluestone) by airplane at the rate of 10 pounds per acre as soon as the shrimp are observed, which is about 2 weeks after the land is submerged. The granular form of copper sulfate is better suited for broadcasting than the dust or coarsely ground forms. The shrimps are killed within 48 hours after treatment. The kill is quicker in shallow than in deep water.

U. S. GOVERNMENT PRINTING OFFICE: 1950

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. Price 15 cents