

Effect of Environment and Source of Seed on Yield and Other Characters in Rice¹

JENKIN W. JONES, C. ROY ADAIR, N. E. JODON, H. M. BEACHELL, AND LOREN L. DAVIS²

ONE of the basic requirements for successful rice production is the use of good seed, that is, relatively pure and viable seed of varieties adapted to the prevailing climatic and soil conditions. It is customary among some rice growers to purchase new seed every few years because of a belief that their seed has deteriorated or "run out". Often the new seed is purchased from other states. This is more expensive than home-grown seed because of transportation costs. The seed of rice, as that of other self-pollinated crops may deteriorate in quality as a result of mechanical mixture of varieties, natural crossing, disease infection, and contamination with weed seeds. The need for purchasing new seed can usually be eliminated, however, by more careful attention to maintaining the purity and quality of home-grown seed.

To determine the effect of source of seed on yield and other characters in rice, an experiment was conducted at four rice experiment stations from 1937 to 1941, and the results are reported here.

MATERIAL AND METHODS

The Caloro (short-grain), Early Prolific (medium-grain), and Fortuna (long-grain) varieties were used. Caloro is the principal variety grown in California, and Early Prolific and Fortuna are important commercial varieties grown in the southern states. Each year seed of Caloro and Early Prolific was exchanged between the four rice stations located at Stuttgart, Ark., Crowley, La., Beaumont, Tex., and Biggs, Calif., and seed of Fortuna was exchanged between the three southern stations.

In 1937, the seed of Fortuna from Arkansas was a slightly earlier strain than regular Fortuna, and in 1940 the seed of Early Prolific from Texas was not entirely typical of this rather non-uniform variety. It is not likely, however, that these minor differences had any marked effect on the average results obtained. The results for 1940 in Louisiana are omitted because the crop was badly damaged by floods.

The experiment was designed to give accurate yield comparisons of the crops grown from seed of the same variety but from different sources. Thus, all plots of the same variety were grown in a group. The lots were randomized within each group and the varieties were randomized within each of the four replications.

The analysis of variance method was used to analyze the yield data. The F test was employed to determine whether a variation was significant. The t test was used to compare the means when the variation in yield was shown to be significant by the F test. For the other characters studied, the t test for small numbers was used to determine whether a difference was significant.

After storage for several weeks under like conditions, composite grain samples of each variety for each source of seed and from each station were well mixed,

¹Contribution from the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Dept. of Agriculture, and the Arkansas, Louisiana, Texas, and California agricultural experiment stations. Received for publication May 15, 1946.

²Principal Agronomist and Associate Agronomists, respectively, Division of Cereal Crops and Diseases.

aspirated twice, and the test weight determined. Samples of each seed lot were soaked for 30 minutes in a 0.2% Semesan solution and then placed between blotters in a germinator at a temperature of 30° C.

Portions of the aspirated samples were sent to W. D. Smith, Grain Branch, Production and Marketing Administration, U. S. Dept. of Agriculture, New Orleans, La., for shelling tests, which were made by Jules J. Deffers of that office. The remainder of each aspirated sample was reduced in size with a Boerner divider and the weight of duplicate lots of 100 seeds was determined. The hulls were then removed by hand from the two 100-seed lots, and the weight of the kernels recorded. The difference in seed and kernel weights gave the weight or percentage of hulls.

The varieties were grown at the different stations, and the yields were recorded by the same men each year. Likewise, the data reported for the other characters studied also were recorded by the same men each year. Thus, the results were not subject to variations due to changes in personnel.

In the text and tables, the stations and sources of seed are referred to as Arkansas, Louisiana, Texas, and California.

EXPERIMENTAL RESULTS

YIELDS

The average yields and the average data for the other characters studied were affected much more by location (station) and season than by the source of seed. Therefore, the source of seed is disregarded and data on the effect of location and season on annual and average yields, and on average data for the other characters studied, are presented in Table 1.

At each station, the annual yield of each variety reported in Table 1 is the average of 12 or 16 plots. The average annual yield of each variety for the three or four stations is based upon a total of 36 to 64 plots, and the 4- or 5-year average yields of each variety are based upon 64 or 80 plots. At each station, the average yields of each variety varied materially from year to year. For example, during the 4- or 5-year periods, the yield of Caloro in Arkansas ranged from 38.9 to 55.3 bushels, in Louisiana from 31.0 to 58.3 bushels, in Texas from 33.0 to 44.2 bushels, and in California from 70.0 to 94.2 bushels per acre. In the same periods, marked variations also occurred in the annual yields of Early Prolific and Fortuna at the respective stations. The environmental factors responsible for such wide annual variations in the yield of the same variety grown on the same soil type by essentially the same cultural and irrigation methods are not too well understood.

The average yields from seed of different sources for the 4- or 5-year period and average data for the other characters studied on the respective stations are shown in Table 2.

In a total of 57 yield comparisons or tests with seed of the three varieties from different sources only 10 showed significant differences. In Louisiana, the average yield of Caloro was significantly higher from California seed than from Arkansas, Louisiana, and Texas seed. The average yields of Early Prolific were significantly higher in Arkansas from the Louisiana and Texas seed than from Arkansas and California seed; in Louisiana, from California and Texas seed than from Louisiana and Arkansas seed, the average yields from the Louisiana seed being significantly higher than from the Arkansas seed; and in California, from California seed than from Arkansas and Louisiana seed.

TABLE 1.—Annual and average yields and average data for other characters studied of three varieties of rice grown at different rice experiment stations in the United States from 1937 to 1941.

Year	Variety											
	Caloro grown in				Early Prolific grown in				Fortuna grown in			
	Ark.	La.	Tex.	Calif.	Ark.	La.	Tex.	Calif.	Ark.	La.	Tex.	Av.
	Yield Per Acre, Bushels											
1937	55.3	58.3	44.2	70.0	49.1	54.1	39.3	52.7	43.2	63.0	45.3	50.5
1938	49.9	31.0	38.4	94.2	46.3	38.2	28.5	83.9	54.8	44.7	46.1	48.5
1939	49.8	49.0	38.0	91.1	31.0	38.6	27.6	75.0	49.9	49.0	37.2	45.4
1940	38.9	—	36.1	92.2	32.5	—	34.0	84.3	34.5	—	44.2	39.4
1941	47.6	29.5	33.0	72.4	50.9	26.9	29.0	57.0	52.5	40.5	38.0	43.7
Av.	48.3	42.0	37.9	84.0	42.0	39.5	31.7	70.6	46.9	49.3	42.2	—
	Test Weight, Pound											
1937	45.0	43.9	45.0	45.0	41.3	41.5	44.6	41.6	42.3	41.8	43.3	42.5
1938	43.3	45.5	47.0	44.0	40.3	41.6	44.8	43.4	43.0	43.0	45.0	43.7
1939	43.6	45.8	45.2	44.3	44.7	42.0	44.9	43.1	42.6	44.3	46.0	44.4
1940	43.0	—	45.0	46.1	42.0	—	43.0	44.9	42.0	—	44.0	43.0
1941	45.3	42.0	46.0	44.3	43.0	—	44.3	43.3	43.0	42.0	45.0	43.3
Av.	44.0	44.3	45.7	44.7	41.5	41.7	44.3	43.3	42.7	43.0	44.7	—
	Germination, %											
1937	99.5	88.5	89.5	99.8	98.0	93.8	95.5	98.5	97.7	97.7	97.0	97.5
1938	96.3	87.3	95.8	98.5	97.8	91.5	96.2	98.8	98.7	94.2	99.7	97.5
1939	99.0	96.0	96.5	97.5	97.8	93.0	97.8	99.2	99.7	98.0	98.7	98.8
1940	96.0	—	93.5	99.8	97.8	—	94.2	99.0	91.7	—	98.2	95.0
1941	96.0	79.0	94.0	98.0	98.2	88.0	95.5	98.2	97.0	93.7	99.7	96.8
Av.	97.1	87.7	93.9	98.7	97.9	91.8	95.9	98.8	97.0	96.0	98.8	—

Grain Weight, mg													
	27.4	27.2	26.0	29.3	27.5	26.6	28.7	27.9	30.0	28.3	29.4	28.2	28.3
1937	27.4	27.2	26.0	29.3	27.5	26.6	28.7	27.9	30.0	28.3	29.4	28.2	28.3
1938	25.2	27.0	25.9	29.5	26.9	24.7	28.0	26.3	29.5	27.1	28.9	29.1	29.0
1939	24.4	26.7	25.7	28.8	26.4	22.0	26.5	26.8	28.8	26.0	27.7	27.4	27.7
1940	26.0	—	25.4	29.8	27.1	25.6	—	26.3	30.3	27.4	29.0	28.9	29.0
1941	25.2	24.5	26.8	27.7	26.1	24.5	26.7	27.9	28.0	26.8	27.7	28.6	28.2
Av.	25.6	26.4	25.9	29.0	—	24.7	27.5	27.1	29.3	—	28.5	28.1	—
Kernel Weight, mg													
	22.6	22.5	21.1	24.0	22.6	20.9	22.7	21.9	23.6	22.3	23.4	22.2	22.3
1937	22.6	22.5	21.1	24.0	22.6	20.9	22.7	21.9	23.6	22.3	23.4	22.2	22.3
1938	20.4	22.1	21.2	24.5	22.1	19.0	21.8	20.5	23.5	21.2	22.6	23.1	22.8
1939	19.5	21.8	20.9	23.4	21.4	16.9	20.6	20.9	22.4	20.2	21.6	21.7	21.8
1940	21.4	—	20.5	24.4	22.1	20.1	—	20.4	23.8	21.4	23.1	22.8	23.0
1941	20.3	19.6	21.8	22.9	21.2	19.0	20.3	21.7	22.1	20.8	21.6	22.8	22.2
Av.	20.8	21.5	21.1	23.8	—	19.2	21.4	21.1	23.1	—	22.5	22.2	—
Hulls, %													
	17.8	17.2	18.9	18.0	18.0	21.2	20.8	21.4	21.1	21.1	20.4	21.4	21.0
1937	17.8	17.2	18.9	18.0	18.0	21.2	20.8	21.4	21.1	21.1	20.4	21.3	21.0
1938	19.3	18.2	18.2	17.0	18.2	23.3	22.2	22.0	20.4	22.0	21.7	20.5	21.2
1939	19.8	18.3	18.5	19.0	18.9	23.4	22.3	22.0	22.3	22.5	22.1	20.8	21.2
1940	18.4	—	19.4	18.0	18.6	21.4	—	22.4	21.4	21.7	20.2	—	20.7
1941	19.4	20.2	18.6	17.3	18.9	22.3	23.8	22.3	21.3	22.4	22.0	20.4	21.4
Av.	18.9	18.5	18.7	17.9	—	22.3	22.3	22.0	21.3	—	21.3	20.8	—
Yield of Whole Kernels, %													
	79.3	68.6	73.4	76.1	74.4	75.6	74.6	73.2	69.6	73.3	66.7	65.8	60.4
1937	79.3	68.6	73.4	76.1	74.4	75.6	74.6	73.2	69.6	73.3	66.7	65.8	60.4
1938	77.1	76.9	79.2	77.7	77.7	71.6	71.5	73.4	73.4	72.7	58.2	73.8	63.3
1939	69.1	72.2	76.1	69.2	71.7	70.4	69.9	73.1	63.6	69.3	62.2	56.6	58.4
1940	78.5	—	67.5	74.3	73.4	74.8	—	74.9	62.2	70.6	70.7	65.2	68.0
1941	75.5	74.6	78.6	80.5	77.3	75.0	63.9	74.2	76.7	72.5	68.1	73.0	68.8
Av.	75.9	73.1	74.9	75.5	—	73.5	70.6	73.9	69.1	—	65.2	66.9	—

TABLE I.—Concluded.

Year	Variety													
	Caloro grown in				Early Prolific grown in				Fortuna grown in					
	Ark.	La.	Tex.	Calif.	Av.	Ark.	La.	Tex.	Calif.	Av.	Ark.	La.	Tex.	Av.
	Yield of Broken Rice, %													
1937	1.6	12.1	5.3	3.8	5.7	1.6	3.4	3.2	7.5	3.9	10.0	27.5	9.8	15.8
1938	2.9	5.4	1.1	3.8	3.3	3.4	6.4	2.1	5.3	4.3	18.0	19.1	3.6	13.6
1939	9.1	6.8	3.0	10.0	7.2	4.3	6.5	3.2	12.5	6.6	13.7	20.8	19.0	17.8
1940	2.3	—	11.4	6.3	6.7	3.0	—	2.1	14.7	6.6	8.0	—	12.8	10.4
1941	4.9	3.5	1.5	1.4	2.8	2.2	11.0	3.2	2.1	4.6	9.1	11.7	5.4	8.7
Av.	4.1	6.9	4.5	5.1	—	2.9	6.8	2.8	8.4	—	11.8	19.8	10.1	—
	Yield of Total Rice, %													
1937	80.8	80.6	78.7	80.4	80.1	77.2	78.0	76.4	77.1	77.2	76.7	76.1	75.6	76.1
1938	80.0	82.2	80.3	81.5	81.0	75.0	77.9	76.4	78.7	77.0	76.2	77.1	77.4	76.9
1939	78.1	78.9	79.1	79.1	78.8	74.7	76.4	76.3	76.1	75.9	75.9	77.0	75.6	76.2
1940	80.8	—	78.9	80.6	80.1	77.8	—	77.0	77.1	77.3	78.7	—	77.9	78.3
1941	80.4	78.1	80.1	81.9	80.1	77.2	77.4	77.3	78.8	77.7	77.2	76.9	78.3	77.5
Av.	80.0	80.0	79.4	80.7	—	76.4	77.4	76.7	77.6	—	76.9	76.8	77.0	—

None of the differences in average yields of Fortuna from different sources of seed was significant.

The average yields of Caloro and Early Prolific for the four stations ranged from 47.8 bushels from Arkansas seed to 51.4 bushels per acre from California seed (Table 2). The average yields of the three varieties for the three southern stations varied from 47.5 bushels from Arkansas seed to 48.6 bushels per acre from Texas seed. These relatively small differences in the average yields of the three varieties from seed of different sources apparently are not significant. The results indicate, therefore, that local seed of good germination, free of mixtures, and free of weed seeds is usually as productive as that obtained from other rice-producing states.

A comparison of the 4- or 5- year average yields of the three varieties at each station shows (1) that in Arkansas, the average yields of the Caloro and Fortuna varieties were significantly higher than those of Early Prolific; (2) that in Louisiana and Texas, the yields of Fortuna were significantly higher than those of Caloro and Early Prolific; and (3) that in California and Texas, the yields of Caloro were significantly higher than those of Early Prolific.

TEST WEIGHT

The average annual test weight of the grain of each variety varied consistently at each station (Table 1). The average test weight of each variety from all stations was essentially the same each year. However, the average test weight of Early Prolific from California and Texas was significantly higher than that of the same variety from Arkansas and Louisiana. The source of seed had no appreciable effect on the average test weight of any of the varieties at the respective stations, as shown in Table 2.

Test weight in rice is affected mainly by (1) the thickness and pubescence of the hulls, (2) stage of maturity when harvested, (3) injury to the developing or mature grain by insects and diseases, (4) the extent of dehulling in threshing, and (5) the amount of trash present, including stems, chaff, mud lumps, and other foreign material. The deleterious effect of certain of these factors on the test weight of the grain can be reduced to some extent by exercising good judgment in determining the proper time to harvest the crop and by careful threshing, cleaning, and storage operations.

GERMINATION

The germination of each variety from the respective stations varied somewhat from year to year (Table 1). The average germination of Caloro and Early Prolific was significantly higher from California and Arkansas seed than from Louisiana and Texas seed, and also from Texas seed than from Louisiana seed. The average germination of Fortuna was essentially the same from the Arkansas, Louisiana, and Texas seed. The average germination of each variety for all stations was, however, relatively high each year, ranging from 87.7% for Caloro from Louisiana to 98.8% for Early Prolific from California and for Fortuna from Texas.

TABLE 2.—Average yields and average data for other characters studied of three varieties of rice grown from seed of different sources at three or more rice experiment stations in the United States in the period 1937-1941.

Source of seed	Variety												Average for			
	Caloro grown in			Early Prolific grown in			Fortuna grown in			Caloro and Early Prolific	Caloro, Early Prolific, and Fortuna					
	Ark.	La.	Tex.	Calif.	Av.	Ark.	La.	Tex.	Calif.	Av.	Ark.	La.	Tex.	Av.		
	Yield Per Acre, Bushels															
Arkansas	46.9	39.5	39.8	84.3	52.6	40.7	34.4	29.6	66.8	42.9	47.1	50.3	43.5	47.0	47.8	47.5
Louisiana	46.8	41.7	37.3	85.7	52.9	43.8	38.6	32.3	68.3	45.8	46.2	48.6	41.1	45.3	49.3	48.2
Texas	47.8	38.5	36.9	81.7	51.2	44.5	42.0	32.9	71.5	47.7	47.5	49.0	41.9	46.1	49.5	48.6
California	51.6	48.2	37.8	84.2	55.4	38.8	42.9	31.9	75.6	47.3	—	—	—	—	51.4	—
Average	48.3	42.0	37.9	84.0	—	42.0	39.5	31.7	70.6	—	46.9	49.3	42.2	—	—	—
	Test Weight, Pounds															
Arkansas	44.2	44.0	45.6	45.0	44.7	41.6	41.6	44.3	43.2	42.8	42.9	42.8	44.8	43.5	43.7	43.7
Louisiana	44.0	44.4	45.6	44.6	44.7	41.3	42.0	44.2	43.1	42.2	42.6	43.4	44.6	43.5	43.4	43.4
Texas	44.1	44.4	45.6	44.6	44.7	41.3	41.3	44.6	43.4	42.7	42.5	43.0	44.6	43.4	43.7	43.6
California	43.8	44.5	45.8	44.7	44.7	41.2	41.5	44.1	43.3	42.6	—	—	—	—	43.6	—
Average	44.0	44.3	45.7	44.7	—	41.5	41.7	44.3	43.3	—	42.7	43.0	44.7	—	—	—
	Germination, %															
Arkansas	98.4	88.0	93.0	99.0	94.6	98.2	93.0	95.4	98.8	96.4	98.8	95.2	98.8	97.6	95.5	96.1
Louisiana	96.4	87.0	93.6	99.0	93.8	97.6	92.0	96.0	99.0	96.2	95.2	97.2	98.4	96.9	95.0	95.5
Texas	96.8	89.5	94.4	99.0	94.9	97.6	90.8	95.8	98.8	95.8	97.0	95.2	98.4	96.9	95.3	95.8
California	96.6	86.3	94.4	98.8	94.0	98.2	90.5	96.2	98.8	95.9	—	—	—	—	95.0	—
Average	97.1	87.7	93.9	98.7	—	97.9	91.6	95.9	98.8	—	97.0	95.7	98.5	—	—	—

	Grain Weight, mg															
	25.5	26.0	25.5	29.0	26.5	24.5	27.3	26.6	28.9	26.8	28.3	28.2	28.6	28.4	26.7	27.1
Arkansas	25.5	26.0	25.5	29.0	26.5	24.5	27.3	26.6	28.9	26.8	28.3	28.2	28.6	28.4	26.7	27.1
Louisiana	25.4	26.4	26.1	29.0	26.7	25.0	27.3	27.3	29.5	27.3	28.7	28.3	28.4	28.5	27.0	27.4
Texas	25.7	26.1	26.1	28.9	26.7	24.3	27.0	26.6	28.8	26.7	28.5	27.9	28.3	28.2	26.7	27.1
California	26.0	26.8	26.1	29.1	27.0	25.1	28.3	27.7	30.2	27.9	—	—	—	—	27.5	—
Average	25.6	26.4	25.9	29.0	—	24.7	27.5	27.1	29.3	—	28.5	28.1	28.4	—	—	—
	Kernel Weight, mg															
Arkansas	20.8	21.2	20.7	23.9	21.7	19.0	21.2	20.8	22.6	20.9	22.4	22.2	22.7	22.4	21.5	21.8
Louisiana	20.5	21.6	21.3	23.9	21.8	19.3	21.3	21.3	23.1	21.3	22.6	22.4	22.5	22.5	21.5	21.8
Texas	20.9	21.3	21.2	23.8	21.8	18.9	21.0	20.8	22.7	20.9	22.4	22.0	22.3	22.2	21.3	21.6
California	21.2	22.0	21.3	23.8	22.1	19.5	21.9	21.6	23.8	21.7	—	—	—	—	21.9	—
Average	20.8	21.5	21.1	23.8	—	19.2	21.4	21.1	23.1	—	22.5	22.2	22.5	—	—	—
	Hulls, %															
Arkansas	18.8	18.5	18.9	17.8	18.5	22.4	22.3	22.1	21.7	22.1	20.9	21.3	20.7	21.0	20.3	20.5
Louisiana	19.5	18.4	18.7	17.7	18.6	22.3	22.0	21.9	21.4	21.9	21.5	20.9	20.8	21.1	20.2	20.5
Texas	18.9	18.8	18.8	17.8	18.6	22.3	22.3	21.8	20.9	21.8	21.4	21.6	21.0	21.2	20.2	20.5
California	18.5	18.2	18.5	18.1	18.3	22.5	22.5	22.3	21.1	22.1	—	—	—	—	20.2	—
Average	18.9	18.5	18.7	17.9	—	22.3	22.3	22.0	21.3	—	21.3	21.3	20.8	—	—	—
	Yield of Whole Kernels, %															
Arkansas	76.2	72.5	75.0	74.8	74.6	73.6	72.5	73.9	70.7	72.7	66.6	57.6	68.0	64.1	73.7	71.0
Louisiana	76.0	73.5	74.9	75.8	75.1	73.8	70.3	74.0	68.4	71.6	63.7	55.8	65.9	61.8	73.3	70.2
Texas	75.2	72.8	74.4	75.6	74.5	73.9	70.7	74.1	67.5	71.6	65.2	56.2	66.8	62.7	73.0	70.2
California	76.2	73.4	75.5	76.0	75.3	72.6	69.0	73.7	69.8	71.3	—	—	—	—	73.3	—
Average	75.9	73.1	74.9	75.5	—	73.5	70.6	73.9	69.1	—	65.2	56.5	66.9	—	—	—

TABLE 2.—*Concluded.*

Source of seed	Variety														Average for					
	Caloro grown in				Early Prolific grown in				Fortuna grown in				Caloro and Early Prolific		Caloro, Early Prolific, and Fortuna					
	Ark.	La.	Tex.	Calif.	Ark.	La.	Tex.	Calif.	Ark.	La.	Tex.	Av.	Ark.	La.	Tex.	Av.	Ark.	La.	Tex.	Av.
	Yield of Broken Rice, %																			
Arkansas	3.7	7.5	4.3	5.9	2.8	5.6	2.8	6.9	10.4	19.4	9.3	13.0	4.9	7.1						
Louisiana	4.0	6.7	4.6	5.0	2.9	6.7	2.6	9.2	13.1	19.5	10.7	14.5	5.2	7.7						
Texas	4.9	7.2	4.9	4.8	2.7	6.5	2.8	9.8	11.8	20.3	10.3	14.1	5.5	7.8						
California	3.9	6.3	4.1	4.6	3.4	8.4	2.8	7.8	—	—	—	—	5.2	—						
Average	4.1	6.9	4.5	5.1	2.9	6.8	2.8	8.4	11.8	19.8	10.1	—	—	—						
	Yield of Total Rice, %																			
Arkansas	80.0	80.0	79.3	80.7	76.4	78.1	76.7	77.6	77.0	77.0	77.3	77.1	78.6	78.2						
Louisiana	80.0	80.1	79.5	80.8	76.7	76.9	76.5	77.6	76.8	76.8	76.5	76.7	78.5	78.0						
Texas	80.0	80.0	79.2	80.7	76.6	77.2	76.9	77.5	77.0	76.5	77.1	76.9	78.5	78.1						
California	80.1	79.8	79.6	80.6	75.9	77.4	76.6	77.6	—	—	—	—	78.5	—						
Average	80.0	80.0	79.4	80.7	76.4	77.4	76.7	77.6	76.9	76.8	77.0	—	—	—						

The average germination of each variety for all stations was essentially the same for each source of seed (Table 2). The average germination of Caloro and Early Prolific for the 4- or 5-year period was significantly higher from Arkansas and California seed than from Louisiana and Texas seed; whereas, the average germination of Fortuna from each of the southern stations was essentially the same. The average germination of Caloro ranged from 87.7 from Louisiana seed to 98.8% from California seed and that of Early Prolific from 91.6% from Louisiana seed to 98.8% for California seed. The average for each variety, however, was above 90%, except for Caloro from Louisiana. Seed with a germination of 90% or above should give good stands of rice at the usual rate of seeding.

In Louisiana and Texas, Caloro and Early Prolific normally mature when temperatures and humidity are relatively high, hence, the grain may be more seriously injured by diseases and insects than that of late-maturing varieties. This may account in part for the lower average germination of Caloro and Early Prolific seed from Louisiana and Texas as compared with that from Arkansas and California.

GRAIN AND KERNEL WEIGHT

Grain (rough rice) weight is affected mainly by variety, location, soil fertility, stage of maturity when harvested, and injury by diseases and insects. The grain and kernel weights of each variety varied somewhat in different years at each station (Table 1), and in some years the differences were significant. For example, the differences for Caloro were significant in Arkansas between 1937 and 1939, in Louisiana between 1937 and 1941, in Texas between 1940 and 1941, and in California between 1937 and 1940; for Early Prolific, in Arkansas between 1938 and 1939, in Louisiana between 1937 and 1939, in Texas, between 1937 and 1938, and in California between 1940 and 1941; and for Fortuna, in Arkansas between 1937 and 1941 and in Louisiana and Texas between 1937 and 1938.

The average annual grain and kernel weights of each variety for the three or four stations did not differ materially from year to year; however, both the average grain and kernel weights of Caloro and Early Prolific for the four stations were lower in 1939 and 1941 than in other years. The 5-year average grain and kernel weights of Caloro and Early Prolific from California were significantly higher than those of the same varieties from the other states. Likewise, the grain and kernel weights of Early Prolific from Louisiana and Texas were significantly higher than those from Arkansas. The sources of seed, however, had no appreciable effect on the average grain and kernel weights for the four stations (Table 2). Fortuna grain and kernels from each of the southern stations were of essentially the same weight.

The higher average grain and kernel weights of Caloro and Early Prolific from California as compared with those from the southern stations are probably due to a more fertile soil and freedom from disease and insect injury in California.

HULLS

Rice hulls are low in value, hence varieties having a low proportion of hulls in relation to grain weight are preferred by millers. In each of the varieties grown, the percentage of hulls varied to some extent from year to year at the respective stations, and the differences between certain years were significant, except for Fortuna in Louisiana (Table 1). For example, the differences in percentage of hulls were significant for Caloro in Arkansas between 1937 and 1939, in Louisiana between 1937 and 1941, in Texas between 1938 and 1940, and in California between 1938 and 1939; for Early Prolific, in Arkansas between 1938 and 1940, in Louisiana between 1937 and 1941, in Texas between 1937 and 1940, and in California between 1937 and 1939; and for Fortuna, in Arkansas between 1939 and 1940 and in Texas between 1937 and 1938.

Caloro and Early Prolific grain from California was significantly lower in percentage of hulls than that of the same varieties from the southern states. In each of the varieties grown, the 4- or 5-year average proportion of hulls was almost identical at each of the southern stations. The source of seed used had no appreciable effect on the average hull content of the grain produced at the four stations (Table 2). Hulls constitute a somewhat lower proportion of the grain weight of Caloro than of Fortuna and Fortuna a slightly lower proportion than that of Early Prolific. In the period grown, the average hull content for Caloro and Early Prolific was less variable than the grain and kernel weights. Of the characters studied, the percentage of hulls and the grain and kernel weights were less variable from year to year than the average yields per acre and the average milling quality.

MILLING QUALITY

Rice of good milling quality yields a high proportion of whole kernels (head rice), hence, a low proportion of broken rice in milling. These two products combined make up the total yield of milled rice. Head rice sells for a higher price than broken rice, so the price paid for a given lot of rough rice is based upon its apparent milling quality, that is, the relative proportions of head, broken, and total rice expected in milling.

In shelling tests, the annual yield of whole kernels and broken rice of each variety at each station varied materially from year to year (Table 1), and the differences between certain years and also between some stations were significant. For example, the differences in yield of whole kernels were significant for Caloro in Arkansas between 1937 and 1939, in Louisiana between 1937 and 1941, in Texas between 1937 and 1938, and in California between 1939 and 1941; for Early Prolific in Arkansas between 1937 and 1938, in Louisiana between 1937 and 1941, in Texas between 1939 and 1940, and in California between 1937 and 1940; and for Fortuna in Arkansas between 1937 and 1938, in Louisiana between 1938 and 1941, and in Texas between 1938 and 1939.

In 1937, the yield of whole kernels for Caloro from Louisiana was significantly less than that from Arkansas and California; for Early

Prolific in 1941 the yield of whole kernels was significantly lower than that from the other stations; and for Fortuna in 1937 the yield of whole kernels from Louisiana was significantly lower than that from Arkansas and Texas. Likewise, some of the average differences in the yield of whole kernels of each variety for the three or four stations were significant. For example, the average yield of whole kernels for Caloro was significantly higher in 1938 than in 1939, for Early Prolific in 1937 than in 1939, and for Fortuna in 1941 than in 1939.

At each station, the highest 4- or 5-year average yield of whole kernels was from Caloro, and Early Prolific ranked second. For Fortuna, the average yield of whole kernels was significantly higher from Arkansas and Texas grain than that from Louisiana but lower than that from Caloro and Early Prolific.

The 4- or 5-year average total milled rice yields of Caloro at each station were significantly higher than those of Early Prolific and Fortuna which were similar.

The average yields of whole kernels from Caloro and Early Prolific for the four stations were much the same from each source of seed (Table 2). Caloro from Louisiana gave a lower yield of whole kernels than Caloro from the other states. Early Prolific from California and Louisiana likewise gave lower average yields of whole kernels than the same variety from Arkansas and Texas. Fortuna from Louisiana gave a much lower average yield of whole kernels than that from Arkansas and Texas. The average yields of whole kernels for Caloro and Early Prolific were essentially the same for all sources of seed. This also was true for the three varieties from the southern stations.

A high average yield of head rice is of course associated with a low average yield of broken rice. The location (station) and the variety had a marked effect upon the yield of broken rice; whereas, the source of seed had no appreciable effect on milling quality or total milled rice yield, nor were the differences for a given variety large at the respective stations (Table 2).

Milling quality is affected by the shape of the grain and, to a marked extent, by the nature of the weather just prior to maturity and during the harvest periods. Hence, wide variations in milling quality of a given variety occur at a given location from year to year, and also within the same area each year.

SUMMARY

An experiment was conducted at four rice experiment stations during the 5-year period of 1937-1941 to determine the effect of environment and source of seed on yields and other characters in three varieties of rice. Some of the differences in average yields and test weights were significant between years, stations, and varieties.

In 57 yield comparisons between seed of three varieties from different sources, only 10 differed significantly. The source of seed had no appreciable effect on the test weight of the grain produced at the different stations. This indicates that local seed of good quality, free of mixtures and weed seeds, is as productive as that obtained from other rice-producing states.

The germination of seed from the different stations was essentially the same for each source of seed, but the differences in germination of the varieties used were significant between some stations and between certain years.

The average grain and kernel weights within a variety were essentially the same for all sources of seed. However, both the grain and kernels of Caloro and Early Prolific from California were heavier than were those from the southern states. The grain and kernels of Caloro and Early Prolific from Arkansas were lighter than from Louisiana and Texas. However, the differences in average grain and kernel weights within each variety were comparatively small for all stations.

The source of seed had no appreciable effect on the proportion of hulls in relation to grain weight, but Caloro and Early Prolific grain from California had lower percentages of hulls than seed of these varieties from the southern states.

At each station, wide variations in milling quality occurred between varieties and years and also stations, but the source of seed had no effect upon the milling quality of the grain produced.