COMPREHENSIVE RESEARCH ON RICE

PROGRAM AREA Genetics and Breeding

PROJECT NUMBER & TITLE 69-2 Discovery of New Sources of Desirable Characterestics in Rice and Determination of Their Genetic and Physiological Usefulness for Improving California Varieties.

PROJECT LEADERS M. L. Peterson, W. F. Lehman, J. N. Rutger

PERSONNEL M. L. Peterson, W. F. Lehman, J. N. Rutger, P. P. Osterli, M. D. Davis, H. Nazarian, J. F. Williams, D. Hille Ris-Lambers, Shiow-Shong Lin

OBJECTIVES:

1. Introduce from abroad, rice strains, varieties, and genetic lines possessing characteristics believed to be useful for breeding improved California varieties.

2. Screen these introductions under several environmental situations to select those believed to be the best sources of important characteristics.

3. Determine the heritability of these characteristics in crosses with parents of known and proven adaptability.

4. Study the physiological response of plants with and without these characteristics to determine their yield and quality.

WORK COMPLETED AND IN PROGRESS:

A. DISCOVERY OF NEW SOURCES OF DESIRABLE CHARACTERISTICS

The Imperial Valley Field Station is serving as an introduction quarantine nursery for new sources of germ plasm for the genetics, physiology, and breeding programs. About 330 new lines selected for cold tolerance by the International Rice Research Institute were grown in 1970, thus adding to the over 400 lines introduced in 1969. In addition, over 3000 lines from the world rice collection were grown in 1970 and will be available for use at Davis and Riggs in 1971. The initial 400 or more lines introduced in 1969 were grown both at Imperial and Davis in 1970. Several short, erect lines whose maturity is similar to Calrose were identified and selected as parents for use in plant height studies. Lines of different plant type (leaf and stem erectness) were selected for use in determination of the optimum plant type for California. The introductions currently are being evaluated for grain quality characteristics desirable for California markets.

Preliminary yield observations indicated that some of the lines may compare favorably with California varieties. Although some were selected for

further yield testing in their present form, the greatest value of the IRRI introductions probably will be as genetic sources of desirable plant type. One program currently in progress is an attempt to combine the seedling vigor demonstrated by several Hungarian varieties with the short statured plant types of the IRRI introductions.

An additional 400 rice introductions of special agronomic value are being assembled under the leadership of the U.S.D.A. in Beltsville, Md. They will be grown in 1971 at El Centro for seed production and evaluation under quarantine. Still remaining to be introduced into our program are 3000-5000 lines from the world rice collection. These also will be grown at El Centro under quarantine in 1971 and observed for useful characteristics in California. Beyond 1971, it is anticipated that only from 300 to 500 lines need be introduced annually, these representing for the most part, improved varieties developed by breeders in other parts of the world. By 1972, rice workers in California should have available, not only the entire world rice collection but also the system for keeping these collections current. This will represent a major milestone for the California rice program.

B. TOLERANCE OF RICE TO LOW TEMPERATURES.

Growing conditions in California are considered to be cold for rice compared with most other rice growing areas of the world except Japan. Under field conditions, this problem occurs both during seedling establishment and during the flowering period. Observations made in 1969-70 indicate these two problems are not necessarily related in the same genotypes. Therefore, they are studied independently.

Seedling vigor and establishment of stands in cold water appear closely related. Among introductions previously made, the variety Italica liverno from Hungary exibited outstanding seedling vigor. Table 1 shows the comparative seedling height and daily growth rates of this variety with Calrose and Colusa at four different temperatures. At 18°C (About 65°F.) this variety was nearly three times as tall 21 days after planting as Calrose or Colusa. Approximately 220 lines representing crosses between Italica liverno

Table 1. Average plant height and average daily growth rates in centimeters of three varieties at four temperatures.

Variety	Temperature - Degrees C				
	15	18	21	24	Mean
	Height in cm at 21 days				
Italica liverno	4.6	22.2	34.5	41.9	25.8
Calrose	2.2	7.8	26.2	30.6	16.7
Colusa	2.4	8.3	23.5	27.5	15.4
Mean	3.1	12.8	28.1	33.3	
	Average daily growth rates-cm*				
Italica liverno	0.25	0.95	1.44	1.86	1.125
Calrose	0.13	0.55	1.22	1.39	0.822
Colusa	0.13	0.39	1.13	1.18	0.708
Mean	0.17	0.63	1.26	1.48	

*28-day period from planting.

plus two additional vigorous varieties and the California varieties Calrose, Caloro, and Colusa are being screened for seedling vigor and seedling cold tolerance. Preliminary data indicate seedling vigor is a heritable trait and can be incorporatedd into adapted varieties.

In a study to determine reasons for differences in seedling vigor, the activity of an enzyme alpha amylase was investigated. This enzyme is responsible for starch digestion in the endosperm. Table 2 shows that five California varieties showed only about 25% as much enzyme activity as the three Hungarian varieties. Four Indica varieties were more than double the activity of the California varieties. The seedling dry weight of these three groups did not exhibit the same ranking order because of the lower seedling weight of Indica types. Although alpha amylase activity may partially explain differences in seedling vigor, it was clear that this was by no means the only factor. Preliminary studies have been completed to investigate heritability difference in alpha-amylase activity.

Table 2. Mean values and ranges of α- amylase activity and growth of 9 day old rice seedlings.

Varietal source	No. of varieties	α- amylase activity		Shoot dry weight	
		Range	Mean	Range	Mean
California	5	22.8 - 56.9	37.66	47.6 - 56.3	50.20
Hungary	3	102.6 - 205.0	159.20	69.7 - 82.3	74.37
Indica	4	85.0 - 129.25	97.25	36.1 - 46.6	42.28

Low temperatures during flowering are believed to be the cause of panicle blanking in rice. An experiment is in progress to determine the effect of temperature, duration of low temperature, and stage of plant development on panicle blanking. If it is found that the symptoms of panicle blanking can be duplicated under controlled laboratory conditions, it should be possible to look for genetic differences in susceptibility to cold at or near flowering time. We believe this is a distinct possibility and should have data to confirm or reject the idea within another year.

C. HERITABILITY OF YIELD AND ITS RELATIONSHIP TO MATURITY.

One solution which has been proposed for the straw residue problem has been the production of varieties which mature early enough so that the straw can be incorporated with the soil before the fall rains. To investigate the feasibility of this approach, a series of selections were made from crosses between Kitaminori, an early maturing variety from Japan and the California varieties Colusa and Caloro.

At Davis in 1970 (a cool season) Colusa headed in 104 days and Kitaminori in 75 days. Selections were made in the F_2 which ranged in heading time from 71 to 104 days. These selections were planted as spaced single plants in the

field in 1970 and the progeny from each of 44 lines were observed for heading date, height, and yield. The original plant selections were made entirely on the basis of heading date and not for yield. The results as shown in Table 3 indicate that as days to heading decreases from 100 days to 78 days, plant height is reduced and yields decline.

Table 3. Relationship between days to heading of selected F_2 plants in 1969 and days to heading, plant height, and yield in 1970 from a cross between Colusa x Kitaminori.

F_2 selections 1969			Parents and F_3 line performance in 1970					
			Lines	Plants	Heading	Height	Single Plant yields/gr	
	Date	Days	No.	No.	Days	Cm.	Average	Range
1.	July 17	71	10	257	78	83	56.8	49.9 - 63.3
2.	July 30	84	9	219	84	92	60.8	50.3 - 72.6
3.	August 6	91	6	157	91	98	63.1	53.2 - 75.1
4.	August 12	97	9	177	96	102	81.4	72.7 - 88.9
5.	August 19	104	10	206	100	104	82.9	72.3 - 93.4
	Parents							
6.	Colusa	-	-	13	104	94	88.5	- -
7.	Kitaminor	-	-	10	75	78	78.3	- -

There were three of the F_3 lines which yielded as much or more than the Colusa parent, all among the later maturing lines.

Also grown in 1970, both at Davis and at Biggs, were 96 F_4 generation lines of the Kitaminori x Caloro cross. On the average the F_4 lines outyielded both parents at Davis, but were intermediate between the parents at Biggs (Table 4). Individual lines yielding higher than Caloro were

Table 4. Average performance of the 96 F_4 lines and the parent varieties at Davis and Biggs in 1970.

	Yield, g/plot		Days to heading		Height, cm	
	Davis	Biggs	Davis	Biggs	Davis	Biggs
Average* of 96 F_4 lines	541	543	87	76	105	127
Caloro	516	658	110	112	105	130
Kitaminori	485	410	79	64	89	101

*Highest individual F_4 line yield at Davis was 690 g; the highest individual yield at Biggs was 712g.

observed at both locations. The F_4 lines were considerably earlier than Caloro at both locations, and somewhat later than Kitaminori. Average height of the F_4 lines was similar to that of Caloro at both locations.

There was no lodging at Davis, but severe lodging occurred at Biggs. The Biggs site inadvertently received a doubled rate of nitrogen topdressing. This resulted in tall plants and contributed to lodging. Another factor affecting lodging was the weaker straw of the Kitaminori parent.

The high heritability (0.92) of number of days to heading indicates that it is quite easy to classify selections for maturity (Table 5). A lower heritability for height (0.62) indicated that it is more difficult to accurately classify selections for height. Heritabilities for yield are presented for each location separately, as it was found that many lines behaved differently at the two locations (i.e., lines which did well at Davis tended to do poorly at Biggs, and vice versa). Within each location about half of the heritable variation for yield was due to genetic variability (Table 5).

Table 5. Heritability of days to heading, height, and yield.

Character	Heritability*
Days to heading, combined locations	0.92
Height, combined locations	0.62
Yield	
Davis	0.53
Biggs	0.52

*Heritability is the proportion of observed variability which is due to heredity, the remainder being due to environmental causes. A heritability of 1.00 indicates that all variation is inherited; a heritability of 0.00 indicates that none of the variation is inherited.

Table 6. Correlations among characters at Davis to Biggs.+

	Days to heading	Yield
Height		
Davis	0.33**	-0.31**
Biggs	0.46**	0.26*
Days to heading		
Davis		-0.13**
Biggs		0.33

+ A positive correlation between two characters mean that as one character increases, so does the other. A negative correlation means that as one character increases, the other decreases.

*, ** Significantly different from zero at the 5 and 1% probability levels, respectively.

Correlations among the three characters were examined in each location (Table 6). Height and days to heading were positively correlated at both locations, i.e., the taller lines tended to be later in maturity. Height and yield were negatively correlated at Davis, and positively correlated at Biggs. Thus at Davis the shorter lines tended to be higher yielding, whereas at Biggs the taller lines tended to yield more. A small negative correlation was found between days to heading and yield at Davis, but the correlation was not significantly different from zero. Thus at Davis it should be possible to select early lines with no loss in yield. At Biggs there was a positive correlation between days to heading and yield, indicating that later lines tended to be higher yielding. However, the positive correlation at Biggs was relatively small, so in practice it should be possible to make progress in selecting for early maturity while keeping yields high.

Table 7. Comparison of 5 highest yielding lines (both locations) with parents.

Lines	Yield g/plot	Days to heading	Height, cm
Average of best 5 lines	625	84	119
Caloro	587	110	118
Kitaminori	448	72	95

An idea of the possible gains from this cross may be obtained by inspecting the average performance of the five highest yielding lines (Table 7). The five best lines yielded more than either parent, and were more than 3-1/2 weeks earlier than Caloro. They were about the same height as Caloro. Since these data are based on only one year's results, caution must be used in their interpretation. It appears, however, that it should be possible to develop significantly earlier lines which are as high yielding as Caloro. Work on blanking, seed size, and protein content of these materials is in progress. Selected lines will be tested again in 1971.

D. INHERITANCE OF PROTEIN.

Protein malnutrition is a problem in many parts of the world. An increase in protein content of rice would improve the nutritional value of the crop, and contribute toward the world-wide elimination of protein malnutrition, and possibly improve its marketability.

In an effort to raise protein content of California rices, 12 crosses were made between high-protein lines and the California varieties. The inheritance of protein and its relationship with kernel characters and yield are being studied.

Preliminary results have been obtained on the variation in protein content in two crosses with Calrose (Table 8). Progenies with protein contents as high as the high parent were observed in both crosses. Considering only protein, the Ku Jung Do parent appears to be a better high protein source

and produces offspring with higher protein content then does Kitaminori. However, agronomic characteristics of Kitaminori are known to be superior to Ku Jung Do.

Further work on protein inheritance in the above and additional crosses is in progress.

Table 8. Variation in protein content of parents and 100 F_2 plants in two rice crosses.

Lines	Protein content, %	
	Average	Range
Calrose	7.27	6.9-8.0
100 F_2 Calrose x Kitaminori plants	7.09	5.9-9.4
Kitaminori	9.20	8.4-9.9
Calrose	7.27	6.9-8.0
100 F_2 Calrose x Ku Jung Do plants	7.72	5.6-9.6
Ku Jung Do	9.35	9.1-9.6

EVALUATION OF THE PROJECT

This project is quite comprehensive as it is following a number of promising avenues of approach simultaneously. Prospects for success in some of them are excellent. Genotypes with many useful characteristics are now in use (seedling cold tolerance, short stature, high tillering ability, early maturity, resistance to lodging, high protein etc.) in numerous genetic, physiological, and breeding programs.

PUBLICATIONS OR REPORTS:

Lehman, W.F., M.L. Peterson, C.R. Adair, L.L. Davis, and R.W. Haubrick, 1970. Rice Introductions Tested for Use in California. California Agriculture 24:4-6.